THE PEDAGOGICAL SEMINARY AND

JOURNAL OF GENETIC PSYCHOLOGY

Child Behavior, Animal Behavior, and Comparative Psychology

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A STUDY OF THE DYNAMICS OF CORTICAL NERVE FUNCTION VI CHARACTERISTICS OF THE RECEPTIVE FUNCTION OF THE CEREBRAL CORTEX FOLLOWING THE UNCONDITIONED STIMULUS*

Gorky Medical Institute, Moscow

P ANOCHIN AND E STRAJ

The problem of the interrelationship between conditioned and unconditioned reactions is of basic importance to the theory of conditioned reflexes, and is closely connected with the problem of the formation of single behavior patterns This problem arose first in the laboratory of Dr Pavlov in connection with the possibility of forming a conditioned reflex in the presence of a distorted sequence of indifferent and unconditioned stimuli

Krestovnikoff, using an indifferent stimulus three-tenths second after the beginning of feeding, discovered that with such a distorted sequence the conditioned reflex was not formed. The conclusion was that the application of an unconditioned stimulus causes an inhibitory process in the cortex. Since the laws of induction of nervous processes, positive as well as negative, were formulated in Pavlov's laboratory, the impossibility of forming the conditioned reflex in the presence of a distorted sequence was explained on the basis of a negative induction from the unconditioned digestive center This point of view was strengthened by a series of subsequent investigations in Pavlov's laboratory, in which the effect of the unconditioned stimulus was tried upon an already established and well fixed conditioned reflex

One of us (P Anochin) has shown in Pavlov's laboratory that the application of the original conditioned stimulus for several days in this fashion, results in a decrease of its conditioned secretory activity This result was explained then on the ground that the application of the conditioned stimulus, immediately after the beginning of feeding, creates a conflict in the cortex between the negatively induced inhibitory process due to the feeding and the positive

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process resulting from the given conditioned stimulus Similar experiments were subsequently performed by a number of investigators in Pavlov's laboratory and identical results obtained (M. K. Petrova, Soloveichik, Wright) Later when the optimal time relationships between the indifferent and unconditioned stimuli were studied more accurately by W. I Pavlowa it was shown that the conditioned reflex may be formed with "overcovering," but being very labile and inconstant it quickly disappears. This fact was proven recently more fully by Vinogradoff. All these experiments lead to the conclusion that though the conditioned reflex may be formed in the presence of a distorted sequence, it is extremely unstable

Since the investigation of cortical nerve function by the method of conditioned reflexes has stepped out of the confines of Pavlov's laboratory, a number of investigators have attempted to attack this important problem on other subjects and with different methods.

Schnieiman, for example, of Bechterev's laboratory, has shown that the working out of a stable conditioned defense reflex in man in the presence of a distorted sequence of the given stimuli—electrical current and indifferent stimulus—is quite possible Unfortunately, the necessary methodical conditions (the time interval, the possible generalization) were not strictly observed in this experiment.

A number of investigators of this problem, chiefly American authors, have shown that such a reflex either does not form at all or proves to be very unstable in man

Cason has shown on the pupillary and winking reflex that the production of a conditioned reflex with a reverse sequence is impossible.

Using the knee jerk and skin galvanic reflexes as indicators, Switzer finds that the formation of a conditioned reflex with a reverse working out is difficult It was only in the case of knee jerks that he noticed in two out of five subjects a mere suggestion of a conditioned response Schlossberg, too, studying conditioned knee jerks, found that the most effective interval between the indifferent and unconditioned stimuli is the interval of .20-.44 sec

It follows from the above described material that the problem of the formation of unconditioned reflexes in man in the presence of a distorted sequence of stimuli is far from being solved; the majority of investigations point out the impossibility of such formation, positive results are very scarce.

Wolfle, in his study of the defense conditioned reflex, withdrawing of the finger, comes to the same results

Some authors have studied the same problem on mice, using the labyrinth method, and have obtained similar negative results, e g., Carr and Freeman came to the conclusion "that the reverse formation of the conditioned reflex is probably impossible"

Yarborough, applying electrical stimuli to mice, comes to the conclusion that it is practically impossible to obtain a conditioned reflex in the presence of a reverse sequence of the indifferent and unconditioned stimuli

This variety of results concerning the "retrograde" formation of the conditioned reflex gave Wenrick the right to speak of the "riddle of the conditioned reflex."

The principal cause for the contradictory reports appears to be, according to Wenrick, the extreme variability of the conditioned response and its dependence upon numerous factors, e g, time interval, intensity of the applied stimuli, age, species of animal, etc. It seems to us that these conditions undoubtedly exercise an influence in general on the formation of a conditioned reaction, but that they can hardly be accepted as determining those nervous processes which make the formation of conditioned reflexes difficult The pointing out of these conditions may give us the possibility of mastering a method for the formation of conditioned reflexes, but it could not explain the close interrelationship and mutual influence of the conditioned and unconditioned stimuli. That is why Pavlov's hypothesis which establishes the influence of the unconditioned stimulus upon the cortex and therefore also on the conditioned reflexes according to the principle of negative induction, goes much further than a mere statement of the time relationships between the applied stimuli

This hypothesis, while giving the general characteristics of the processes that take place during the action of the unconditioned stimulus, leaves out, however, many problems which arise upon a closer examination of these processes.

And indeed, how does this negatively induced process spread itself in the cortex? Does it embrace the whole cortex, or only those systems which are associated with the digestive reactions? Is the receptive function of the cortex possible during the action of unconditioned stimuli, and in general is the associative function of the central nervous system as a whole possible during such a moment?

All these questions inevitably arise as soon as we approach a finer analysis of the composition of the unconditioned and conditioned reactions.

In one of our papers (P Anochin and E. Stresz) we have shown that the special substitution of the unconditioned stimulus in the process of the experiment—meat, instead of the usual bread—brings about very complicated changes in the nervous activity involving the subcortical as well as the cortical apparatus, because of the functional connection of its complexes.

These investigations convinced us that negative induction of the cortex resulting from the application of an unconditioned stimulus is not universal for the whole cortex, but that on the contrary some of its systems enter into a positive, more intensive than usual, connection with the unconditioned stimulus.

That is why we concern ourselves in the present investigation with a more detailed study of cortical function during the whole period of the application of the unconditioned stimulus

APPARATUS[1]

In choosing the method of investigation we decided to utilize the *wealth of possibilities for analysis which* Pavlov's method of conditioned reflexes offers, but along with it we thought it necessary to introduce into this method the possibility of synthesis of complicated nervous acts The most complete synthesis of nervous activities expresses itself in what is ordinarily called "active choice."

The animal organism stands out in this "active choice," from the standpoint of its nervous manifestations, as a dynamic whole, and these manifestations must fully characterize the behavior of the animal.

Introducing a specially constructed stand and placing the animal in the identical condition of the classical experiment for the conditioned reflexes, we obtained a combination of the two above mentioned principles.

The stand has two plates in the right and left side and the animal

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[1] This method has been described in detail (P Anochin) in Russian Literature It is presented here briefly for American readers.

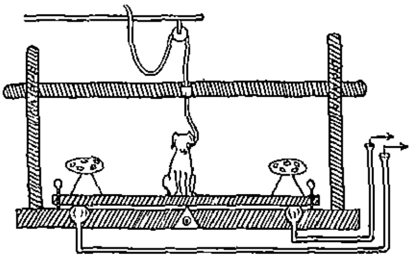

FIGURE 1

Scheme of Experimental Stand for the Simultaneous Study of Secretory Conditioned Reflexes and Motor Choice of Dogs

The movements of the dog are exactly recorded by Marey's capsules.

in the center of the stand has the usual conductor for pneumatic transmission on a manometer and an electric writing-needle (Figure 1). The upper plank of the stand balances on a central hinge and its swings are transmitted on capsules—with the help of two rubber balloons, into the experimenter's room.

Since any of the conditioned stimuli may be connected with either side of the stand we have the possibility of placing the animal in a condition whereby we can study not only the secretory effect of any given stimulus, but also the animal's active choice of one or the other side—which makes it possible to study simultaneously the secretory and motor function of the animal.

With the above described technique we approached the solution of our problem

The Experiment

Prior to the development of the "overcovering" proper according to the above described technique we performed a number of tests in order to study the cortical activities during the action of the unconditioned stimuli.

This series of experiments can be divided into three periods

(*a*) The giving of the conditioned stimulus on the left side during feeding on the right without the reinforcement on the corresponding left side.

(*b*) The giving of the conditioned stimulus during feeding on one side reinforcing it with a second plate on the opposite side.

(*c*) The giving of the opposite plate only without a preliminary conditioned stimulus, at different intervals of action of the unconditioned stimulus of the given side

The experiments of the first period were performed in the following order: the animal had two old, stable conditioned stimuli· a bell on the left side and a tone *A* for the right side. The dog was given as usual the tone *A*, reinforced with food on the corresponding right side. At two seconds after beginning of the meal the ringing tone was discontinued, and three seconds later when the animal was still continuing to eat, the bell, the conditioned stimulus of the left side, was introduced, the action of which was finished several seconds before the end of the meal.

The first trials of this kind have shown that the animals do not manifest objectively any effect of the second conditioned stimulus and that they return after the meal to the middle of the stand. On the basis of these observations one might think that the conditioned stimulus given secondarily does not produce any changes in the cortex of the large hemispheres, and remains therefore unnoticed by the animal. Some peculiarities in the behavior of the animal make us believe, however, that the situation is somewhat different Usually after feeding, in connection with a given conditioned stimulus, the animal returns to the middle of the stand and waits there till the next conditioned stimulus. Here, however, after the introduction of the second conditioned stimulus during the feeding, the animal, after getting through with the meal, runs several times to the opposite side, i e., to the one which the "overcovering" conditioned stimulus signals, and persistently sniffs the plate And since this "overcovered" stimulus was not reinforced with food in this initial set of experiments, the animal stopped coming over to the opposite side after 6 to 8 trials

These experiments convince us, therefore, that the conditioned stimulus, given during feeding, is perceived by the animal in its proper meaning, i e, as a feeding signal on the opposite side Because of the absence of adequate support, its action could not develop to such an extent as to give a corresponding motor reaction

We began therefore to reinforce the "overcovered" conditioned reflex on the corresponding left side

The very first application of reinforcement convinced us that the conditioned stimulus given during eating develops all the nervous activities characteristic of it On the first giving of the food on the left side during the meal on the right, the animal interrupts its meal on the right side and runs to the left There it eats the given portion and returns to consume the remaining food on the right side. True, it was the sound of the plate that the animal was responding to, because to the conditioned stimulus itself it did not respond at first But the sound, nevertheless, represents a definite conditioned stimulus and its action must therefore spread primarily in the cortex of the large hemispheres We are giving here a curve which shows the conditioned motor reactions to the sound of the plate (Figure 2).

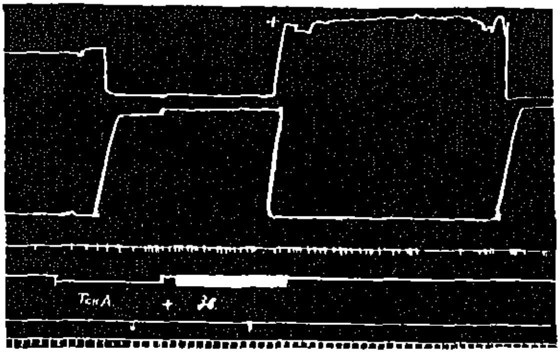

FIGURE 2

After the *A*-Tone Ceased and the First Feeding (Right Feeding-Cup) Was Given, a Bell Was Rung, Signalizing Left Side-Feeding

The bell itself did not stimulate any motor reaction of the dog, but the appearance of the left feeding-cup caused a quick motor reaction to the left (marked by the cross) After eating the portion on the left side, the dog turned back to the right and ate the food remaining there

Upper line run to the left; second line, run to the right, third line, secretory reaction, fourth line, conditioned stimulation, fifth line, unconditioned stimulation; sixth line, time-mark (intervals of 2 seconds).

It was further shown that after five reinforcements of the "overcovered" conditioned stimulus with the corresponding plate, the stimulus in itself became sufficient to interrupt the meal and bring out a motor reaction to the right side. We present a curve of one of such experiments in which the "overcovered" conditioned stimulus has interrupted the curve of the unconditioned reflex (Figure 3)

The above experiment is interesting in several respects. To the first conditioned stimulus, the bell, the animal did not respond with

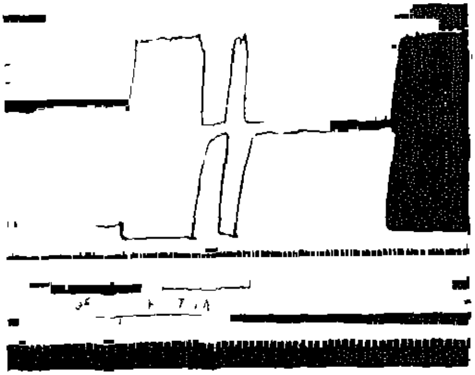

FIGURE 3

POSITIVE CONDITIONED REACTION TO *A*-TONE, GIVEN WHEN THE ANIMAL WAS FED

Not finding any bread at the side for which the signal was given the dog returned again to its former place At the sound of the feeding-cup, however, the dog ran again to the right and ate the bread there

the usual motor reaction, the response occurred only upon the presentation of food Eight seconds after the beginning of feeding, the second conditioned tone *A* was given and as seen from the curve it interrupted the eating, bringing out a motor reaction to the opposite plate. Not finding any food there, because it was served only 15 seconds after the giving of the "overcovered" conditioned stimulus, the animal returned to the left side and continued to eat the first portion But the sound of the plate to the tone *A* would again provoke a motor reaction to the right side, and the animal began to eat the food in the right.

Having finished it, as seen from the graph, the animal returned to the left side and finished the remaining food there The above graph shows that the receptive function of brain cortex of the experimental animal is not reduced during the feeding, but that it is increased in respect to digestive stimuli The proof lies in the fact that the animal did not manifest any motor reaction to the first strong conditioned stimulus (the bell), but to the second, weaker stimulus (tone *A*) given during eating it responded with a very complicated motor excursion to both sides of the stand. This case is not an isolated one, motor reaction to an "overcovered" conditioned stimu lus takes place very frequently with any combination of stimuli. As for example, in the very same experiment, the curve of which was just presented, we obtained a motor reaction to the opposite side, when the bell was given after the tone The animal would leave the food on one side, run to the opposite side and wait there persistently, as long as the "overcovered" stimulus was effective, the serving of the plate It is necessary to point out here that all of our conditioned stimuli signal the same unconditioned stimulus, in quality as well as in quantity (25 gm of toast)

It is also important to point out that after the introduction of the second feeding in connection with the additional conditioned stimulus, the animal would, as a rule, after finishing the meal on one side run to the opposite side and sniff the plate, even when only one of the stimuli was given As it normally returns to the middle of the stand after completing the meal, we have to recognize this running to the opposite side as a newly developed conditioned motor reaction We draw particular attention to this circumstance since this development was taking place during the action of the unconditioned stimulus.

We became interested in finding out the dependence of the motor conditioned reaction upon the time of serving of the second plate in relation to the beginning of eating of the first With this in mind we performed a whole series of experiments, giving the plate only during eating on one side This plate was served at different intervals after the start of the eating process

These experiments were justified in that one might have assumed a difference of action of the unconditioned stimulus on the cortex during the different moments of eating We have taken the following time intervals 5, 8, 10, 12, 15, 20 seconds. We give here a compound table of a number of experimental days with tests at different time intervals (Table 1).

The cross in the graph represents the motor reaction of the animal to the serving of the opposite plate during eating of the first portion This reaction has no definite relation to the time interval.

But along with it stands out quite clearly the dependence of this reaction upon the number of applications one observes a gradual development of a negative reaction although the animal, after finishing the first portion, rushes over to the opposite side where a plate was placed while it ate the first portion

TABLE 1

Time interval between the beginning of the first feeding and the serving on the opposite side	Number of the experiments										
	248	249	250	252	253	254	259	164	265	266	267
5 seconds	+	+	—	—	—	—					
8 seconds	+	—	+	+	—	—	—	—	—	—	—
10 seconds	—	—	+	—	—	—	—	—	—	—	—
12 seconds	+	+	+	—	—						
15 seconds	+	—	—	—	—						
18 seconds	—	+	—	—							
20 seconds	+	—									

This indicates that the animal fully perceived the sound of the plate, but after a while began to postpone the reaction till the end of the meal One can hardly associate this fact with an increased inhibitory action of the unconditioned stimulus on the cortex, rather should one accept it as a special form of the animal's adaptation to the new condition of the experiment And indeed, even during the period when the plate stopped exercising its influence, the application of the artificial conditioned stimulus during the process of eating, would interrupt this process and bring about a motor reaction of the animal.

The reaction, "going away from food," to the sound of the plate began to fade, but returned upon the application of the conditioned stimulus It is difficult to associate the obtained reaction of going away from food with any state of food stimulation In some cases it manifests itself at the end of the experimental day, not showing itself at the beginning of the day, and in others the reverse takes place

One can therefore make but one certain statement concerning this reaction: it is extremely labile and subject to many modifications.

In the second part of our investigation we decided to utilize such peculiarities of the cortex of the large hemispheres which we observed during the action of the unconditioned stimulation. The cortex is capable, during the action of the unconditioned stimulus, of performing complicated associative acts It is, however, essential that this activity should proceed according to the rule. "signal-reinforcement."

Taking all this into consideration we decided to work out a conditioned reflex to a new, indifferent stimulus, applying it in the usual "overcovering" manner, i e., several seconds after the beginning of eating, introducing, however, the very essential addition that this stimulus was the signal for feeding on the opposite side. The whole combination of stimuli had to assume, therefore, the following form· The old conditioned stimulus, tone *A*, is given at first, being reinforced with food in the corresponding left side of the stand After the beginning of eating, a new conditioned stimulus, *FAN* is introduced which lasts 15 seconds and is discontinued half a second before or at the moment of introduction of the plate on the opposite (right) side The basic condition of this combination is obviously the fact that the new stimulus was acting only during the application of the unconditioned stimulus. It was thought, of course, that the animal would run to the opposite plate without food, only then could one speak of maintaining the principle "signal + reinforcement."

The fact that the animal towards the end does not interrupt eating to run to the opposite plate, but consumes both portions, indicates that it adapted itself more economically to the new situation of the experiment A similar process occurs evidently in those cases when the rat picks the shorter route of the labyrinth, avoiding the longer one

To obtain a constant motor reaction to the sound of the plate we performed the following· if the animal did not interrupt eating at the serving of the opposite plate we automatically removed this food and replaced it with an empty plate. As the experiments show, the animal reacted to this procedure with a quick motor reaction to the opposite plate, the one it used to ignore previously Furthermore, there manifested itself a very interesting detail indicating the high degree of activity of the cortex of the large hemisphere during the action of the unconditioned stimulus. After the food had been removed several times, the animal began to interrupt eating systematically as soon as the opposite plate would be given And since the sound of the *FAN* in this set of experiments always preceded the taking away of food, we obtained here quite unexpectedly a new conditioned reaction As soon as we introduced the *FAN* during the feeding period in the left, the animal would begin to swallow quickly the given portion, fill its mouth and run to the opposite side This curious fact convinced us that the indifferent stimulus

FAN given during the eating process, though unnoticed by the animal, became both a conditioned signal of removal of one and the serving of another portion of food on the opposite side.

This serves only as additional proof of the concept that stimuli, acting in the central nervous system during the action of unconditioned stimuli may enter into a diversity of combinations with different nervous complexes The fact that on the eighteenth application of the *FAN* the animal left the food on the left side and ran to the right even before the serving of the plate on that side is a final confirmation of the above conclusion (Figure 4)

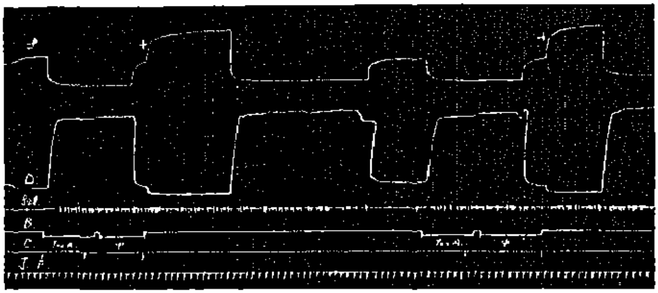

FIGURE 4

The Dog Left the Food at the Right Side, Ran to the Left and Awaited Confidently at the Chosen Feeding-Cup

This first conditioned motor reaction to the sound of the *FAN* possesses a definite direction and persistence. After tearing itself from food on the left side, the animal awaits quite stubbornly (about 8 seconds) food on the right side. We attempted further to stabilize this reflex, training it 50 times in the same setting, and then making the isolated trial in the usual sequence, "*FAN*-reinforcement," without the preliminary giving of food and the other conditioned stimulus One has to take into consideration, of course, all that we have said previously concerning the modification of experimentation during important tests

In the conditions of our experiment, the *FAN*, which is usually given only with food, is given for the first time separately. The experiment has shown that the animal reacts to the isolated *FAN* with an increased oriented investigative reaction, but the secretory

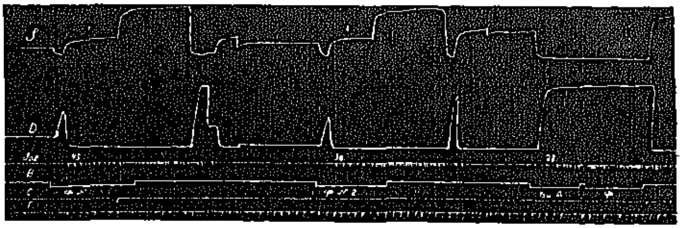

FIGURE 5

First Isolated Stimulation by Fan After 50 Overlappings

Note the motor reactions to the left (marked with cross) and the abundant secretory reaction The dog does not choose the side at random, since during all the 15 seconds of isolated stimulation he stands near the chosen feeding-cup

and motor reactions were quite distinct, the last being quite adequate to the side where the *FAN* was usually reinforced (Figure 5).

The persistent motor reaction (marked with a cross) to the left side and a considerable conditioned secretory reaction are seen on this curve quite distinctly

This last test fully convinced us that the conditioned-reflex activity during the action of the unconditioned stimulus may take place quite normally without any increase in time for its development. This test practically solved the basic problem we were confronting From then on we gave the isolated *FAN* only, according to the usual method, paying particular attention to the character of the motor reaction, as well as to the conditioned secretory component The latter giving with the first application 45 and 30 scale divisions in 15 seconds, remained subsequently at about the same level, indicating that the process of its conditioned development has already been completed during its application on the background of the unconditioned stimulus

The motor reaction proceeded with variable success, but did not differ materially from the motor reaction to the other conditioned stimuli (tone, bell).

Conclusions

1. A conditioned stimulus on the right side, given during the action of the unconditioned stimulus on the left side, may interrupt the course of the unconditioned reaction and provoke a motor-conditioned reaction

2 The possibility of a conditioned motor reaction during the action of the unconditioned stimulus indicates that the latter does not exercise an inhibitory action on the cortex of the large hemispheres.

3. The indifferent stimulus given 3 seconds after the beginning of action of the conditioned stimulus may become a conditioned stimulus for feeding on the opposite side of the stand.

4 The central nervous system is capable of realizing a very complicated positive associative activity at the time of action of the unconditioned stimulus, and manifest an adaptibility to the changing conditions of the experiment.

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THE ESTABLISHMENT OF A CRITERION OF DEPTH OF SLEEP IN THE NEWBORN INFANT*[1]

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Criteria of Sleep in the Neonate

In spite of centuries of speculation, description, and more recently, experimentation concerning the problem of sleep, few attempts have been made to define "sleep" accurately. Up to the last decade, investigators apparently assumed that they knew what sleep was and hence needed no objective standard for determining it. Their criteria, whatever they were, remained subjective and unformulated.

The need for an objective criterion is not so apparent when we consider adult man, with his fairly definite rhythm of nocturnal quiescence and diurnal activity. However, in the case of the newborn infant, where this rhythm is not so definite, the need for a criterion of sleep becomes manifest.

This obvious necessity was not recognized until a few years ago. Soon after a few concrete definitions of adult sleep were proposed, experimenters began employing objective criteria of sleep in studying the behavior of newborn infants. In 1930 Pratt, Nelson, and Sun (19) used "eyes closed" as a sleep criterion in the newborn, if one adopts the definition they gave in a preliminary description of the control period. However, the criterion apparently was modified slightly before their experiments were concluded, for on page 169 they stated that "the term 'asleep' means that the infants' eyes were closed and body inactive when the experiment started."

Irwin (11) used the criterion, "eyes closed and quiet." Bryan (1) defined the sleeping period as that occurring right after feeding, but made no further specifications. Richter (20) apparently used high electrical skin resistance as a criterion of sleep in both infants and adults. Infants less than one year of age were considered asleep by Marquis (16) when the eyes had been closed for one minute. Pratt

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(18), in a discussion of sleep in the neonate, decided that there were as yet no adequate criteria of that condition

In the later work of Irwin and his students, Weiss and Stubbs (14, 22, 24), the condition, "asleep," was not defined, but perhaps we may again assume that they were using the same definition earlier adopted by Irwin, that of eyes closed and body quiet

In the recent studies in infant behavior made at Ohio State University, Disher (7), like Delman (5) a year later, used closed eyes and lack of observable movement as criteria of a condition of sleep which was always required preceding the application of stimuli Similarly, Taylor (23) remarked that "it is always difficult to describe what is meant by sleep, and in the case of infants the task is even more difficult Following Disher, we have assumed that the infant is asleep when eyes are closed and when it is making no observable skeletal movements" (Page 72) Dockeray and Rice (8), like these other experimenters, were concerned with a description of "sleep" only in order to describe the conditions accompanying the presentation of stimuli

> In order to observe the reactions which could be attributed to the stimulus, it was necessary that the infant should be quiet, or "asleep" The only criterion of this condition was that the infant had not moved for at least one minute before the stimulus was applied In nearly all instances the eyes were closed In several cases the breathing of an infant indicated that he might be more deeply asleep than at other times, but as yet there is no objective evidence for such an assumption (Page 86)

PURPOSE OF THE PRESENT INVESTIGATION

After considering these various criteria, the question arises as to whether or not it is possible to establish a more accurately described criterion of sleep in the newborn infant Only by this means could we answer such queries as Is regular breathing important in defining infant sleep? Are there different stages of sleep depth in infants such as investigators have described in adults? How continuous must infant immobility be in order to call it sleep? Are there variations even within a condition of "sleep," as described by any one investigator so far, which might be determined analytically? Is sleep a condition definite enough for us to state that the infant spends a certain proportion of its early life in sleep?

The establishment of an adequate criterion of sleep, which indirectly will enable us to answer the above questions, is the purpose of this investigation This criterion will apply to newborn infants during the first ten days of life

The point of view taken here is closely akin to that described by H M Johnson (15) a few years ago· "We shall say that an organism is awake to those changes to which it responds by specific movement, to all other changes we shall call it asleep" (Page 24). Sleep thus is partial and not absolute.

However, Johnson has recently added that sleep is not measurable, and therefore the term "sleep" is not applicable to any studies heretofore employing that name But it is conceivable that a statement that sleep is not measurable is just as arbitrary as that sleep, within specified limits, is measurable And if the term "sleep" is given a carefully restricted connotation, certainly there could be no objection to the use of the term We agree that the word "sleep" is widely misused and little understood, and that it would no doubt be preferable to discard it entirely. But since the term is deeply rooted in the popular vocabulary, we can at least redefine it and retain it in order to indicate the bearing which our present study has upon the misinformation which the layman calls "sleep"

As a starting point in this study, we do not assume that there are two separate categories of "sleep" and "waking," but that sleep is relative, *and exists in different degrees or depths An infant is deepest* asleep to that stimulus to which it makes no measurable response, and less deeply asleep when it makes a measurable response. There may, of course, be responses for whose detection we have no appropriate measuring devices Therefore, where we speak in terms of response, we refer here to those responses measurable with the apparatus employed in this particular experiment

Now if an infant merely flexes its toes in response to one stimulus and moves its entire body in response to another should we say it is equally asleep to both stimuli? It seems logical to consider it less deeply asleep to the stimulus to which it makes the greater response Taking an infant in any condition whatsoever, then, we can apply various stimuli and observe the responses made, judging the infant as being less deeply asleep to those stimuli to which it responds more.

In what sense does an infant respond more? This could mean (*a*) a more vigorous response, (*b*) a more extensive or widespread response, in terms of body parts, or (*c*) a longer response, one of greater duration. In the first part of the present study an attempt was made to use all three indices of a "greater" response But when various responses were classified as vigorous, moderate, and slight, it was found extremely difficult to establish an objective standard for making the classification Granting that a distinction could more easily be made between "vigorous" and "slight" than between either of these and "moderate," two classifications alone would furnish little additional *sensitivity to a differentiation* of responses as "more" or "less" We are left, then, with two indices for differentiating responses to stimuli the extent of response, and the duration of response These shall be used in the discussion of results to be presented hereafter.

Assume, then, that we have found that infant *S* at certain times *makes no response to a needle-prick on the big toe, or merely moves* its toes slightly We say, then, that *S* is deepest asleep at such times, at least with reference to the needle-prick. Suppose that another investigator wants to use a similar stimulus with infant *R*, while it is deepest asleep, in order, say, to determine the latent time of its response Must he keep on pricking *R*'s toe until *R* finally fails to respond or makes only a slight toe response? *Or could we not find a* certain overt pattern of relative immotility in the infant which always accompanies its minimal response to the stimulus? If so, we could give a specific description of this observable pattern so that the other experimenter could ascertain the period of deepest sleep in infant *R* merely by observing *R* closely instead of stimulating *R* constantly to determine that period

We therefore proceeded to make an extensive classification of all possible conditions of motility on the part of the infant, and then observed the responses made to stimuli in these various conditions in order to find out whether or not they were indicative of different *stages in sleep depth with reference to the stimulus in question* Depth of sleep, as mentioned before, was determined on the basis of the relative duration and extent of these responses to specific stimuli This classification is given in a discussion of the method of the experiment

So far so good But suppose this aforementioned experimenter with infant *R* wishes to study *R* while deepest asleep to another stimulus, such as the odor violet. May he assume that *the overt pattern* described for deep sleep with reference to a needle-prick on the big toe is the same as for the odor violet? In other words, is sleep specific or general—is an infant, who is deepest asleep to a needle-prick on the toe, also deepest asleep to all other types of stimuli? To answer this question the experimenter applied a variety of stimuli and then compared the responses made in each of the conditions specified

Many other questions arise which must be answered by the present investigation If we can describe, in terms of overt motility, several stages of progressively deeper sleep for one infant, will these stages be applicable to all other infants? The answer to this question can be ascertained by comparing the responses made in each described condition by a large number of infants. Will these stages vary according to the intensity, duration, and point of application of each stimulus? While intensity and duration were kept constant for each specific stimulus in this study, comparison could be made of responses to stimuli applied at the various points designated

There will be, of course, many questions concerning the sleep of the newborn infant which cannot be answered by the present study This is to be expected This study lays the foundation for further research dealing with numerous other angles of the problem by first determining when and how deeply an infant is asleep to specific stimuli. From this point we can proceed in the future to attack other phases of the problem such as the change in *G S R* in the sleep of the newborn, the change in fontanelle pulse during sleep, and the relative amounts of time spent in various depths of sleep.

APPARATUS

Each infant studied was placed in the experimental cabinet earlier constructed and described by Pratt, Nelson, and Sun Temperature was maintained between 85 and 90 degrees Fahrenheit by means of the heating unit in this cabinet Illumination consisted of the "cold light" of the neon grills described by Irwin (12) One side of the cabinet was open to give the experimenter access to the infant, although this opening was protected by a heavy curtain. Observations were also made through the small "window" at one end, directly above the polygraph platform fastened to the outside wall of the cabinet All data were recorded on the polygraph tape.

For one portion of the investigation the stabilimeter employed by the aforementioned experimenters was used, but was eventually discarded for reasons to be discussed later Breathing records were secured by means of a pneumograph consisting of a small partially inflated rubber balloon held securely over the infant's abdomen by a gauze band, pressure changes were transmitted to a Marey tambour recorder which made an ink tracing upon the polygraph tape Another tambour recorded a stimulus line. Presentation of a stimulus was indicated by pressing a rubber bulb. A pneumatic device was used in preference to one involving an electromagnet in order to eliminate as much external auditory stimulation as possible. A preliminary setup with the latter type of stimulus line gave loud clicks which occasionally elicited overt response from the infant. For a similar reason the time line was finally omitted, and time measurements were made in centimeters, as the tape ran at a constant speed.

For the pain stimuli, the device described by Dockeray and Rice was used. "The stimulus was applied by means of a fine needle inserted through a small block of rubber so that the point of the needle projected approximately one-sixteenth of an inch. The rubber was tapered at the needle-point and to avoid contact with the skin" (Page 86).

For the tactual stimuli a camel's-hair brush was used. The experimenter at first considered making a device with which pressure could be controlled mechanically, but finally decided that with careful practice in handling the brush in a specified manner, the amount of pressure exerted could be regulated about as consistently as with a type of apparatus such as that described by Pratt, Nelson, and Sun.

For the auditory stimuli the experimenter used a Western Electric *2-B* audiometer with a Western Electric *34-A* amplifier and a dynamic speaker. Two frequencies, 256 and 2048, of a fixed intensity, were arbitrarily chosen as representative of low and high pitches respectively, after preliminary observations were made by the experimenter and another observer with a variety of frequencies and intensities. The audiometer and amplifier were placed on a low platform in front of the cabinet, while the loud speaker was placed at a distance of six inches from the ears of the infant lying on the platform. The intensities of the auditory stimuli at this point six inches from the loud speaker were 22 dynes per square centimeter at the frequency of 256 cycles and 24 at 2048 cycles.[2]

For the olfactory stimuli the experimenter used the apparatus constructed and described by Disher (7). A complete description of her constant-temperature box and its incidental equipment can be found in the report of her research with "chemical stimuli administered nasally." Only five of her eight stimuli were used, however: pyridine, violet, sassafras, turpentine, and lemon.

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[2] We are indebted to Professor W. L. Everitt of the Communications Laboratory, Ohio State University, who calibrated the instrument in the infant's cabinet.

SUBJECTS

The experiment was carried on in the psychology laboratory on the fourth floor of the University Hospital, in one wing of the maternity ward. The subjects were normal full-term infants from the clinical ward and varied in age from three hours to 10 days, though in Part 1 results from three infants 11 days old were included. The majority of the infants were first-born, and hence the median age of the mothers hovered about 18 or 19. All infants reported "colored" on their records were classed as colored, although in some the percentage of colored blood was so small that there were no negroid characteristics apparent in the infants. Many of the mothers were unmarried, and practically all the parents were of low socio-economic status.

TABLE 1
SUBJECTS USED IN EXPERIMENT

	Color		Sex		Total Subjects	Total Trials
	White	Colored	Girls	Boys		
Part 1	61	39	50	50	100	180
Part 2	37	26	27	36	63	90
Part 3	18	16	15	19	34	69

Hence a total of 197 infants was studied in a total of 339 trials, with 5342 separate stimuli.

METHOD

General Procedure. Our study is divided into three parts according to the temporal sequence in which these portions of the investigation were performed. Part 1 includes only pain stimuli, consisting of needle-pricks applied to the big toe. Part 2 includes pain and tactual stimuli, applied at various points, and olfactory stimuli. Part 3 includes only auditory stimuli.

The presentation of each stimulus was kept as constant as possible. Pain stimuli were applied at one of several points: (*a*) the middle of the cheek, (*b*) forearm—outer surface midway between wrist and elbow, (*c*) hand—back edge of palm, (*d*) leg—outer surface midway between knee and ankle, or (*e*) big toe—about center of bottom. If the infant gave no overt response to the first prick, the stimulus was repeated at four-second intervals until some response was observed. A limit of ten consecutive stimuli was arbitrarily set, even though no response occurred to the tenth stimulus. This repetition of pain stimuli does not apply to Part 1

Tactual stimuli were likewise applied at one of several areas. (*a*) cheek—brushed from level of nostril toward the ear for a distance of about 2½ inches; (*b*) nostril—tip of brush placed at nostril at moment of inspiration and drawn across edge of nostril; (*c*) lower lip—brushed from infant's right to left just above cleft in chin, for a distance of about 2 inches, (*d*) hand—brushed in an arc from mount at base of thumb across center of palm to lower outer edge; (*e*) foot—sole brushed from heel upward in median line to point just below third toe.[3]

The pressure of the tactual stimulus was kept practically constant by holding the brush as nearly perpendicular as possible to the surface stimulated, deflecting the camel's-hair point about half its length The experimenter practiced frequently on her own hands to obtain in addition a subjective impression of pressure equality

As with the pain stimuli, within a limit of ten the tactual stimuli were applied until an observable response was obtained Four seconds elapsed between the beginning of one stimulus and the beginning of the next, approximately three seconds were required for the brush stroke itself, and about one second for shifting the brush point back to its initial position

The odors were applied in the manner specified by Disher With any given odor, 20 cc. of a saturated solution were drawn off into the hypodermic syringe, whose outlet was then pointed directly into the nostril of the infant at a distance of about one centimeter from it. An interval of five seconds was required for the release of the stimulating substance in order that the air current would produce no tactual stimulation Olfactory stimuli were not summated, for adaptation to the stimulus might have occurred. The odors presented were always at least five minutes apart in order to allow for such possible adaptation effects.

Each auditory stimulus was of five-seconds duration Here again no attempt was made to summate the stimulus effects by serial repetition. The stimuli were presented in such a way that there was no abrupt beginning or termination to the sound, since some investigators have reported infant responses to sudden stimuli of any variety

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[3] To answer the question as to whether the direction of stroking altered the results, the experimenter inserted several stimuli where the sole was stroked from the toes downward There was no indication of a differential response

The serial presentation of each type of stimulus was practiced by the experimenter in several preliminary trials, ignoring the responses, but watching an electric clock in order to time the presentation correctly These practices were repeated from time to time throughout the investigation, and also checked afterward by measuring the time intervals indicated on the stimulus line

Simultaneously with the application of each stimulus, the bulb for the stimulus line was pressed. If the stimulus presentation required the use of only one hand, the bulb was pressed with the other hand But if the stimulus presentation required the use of both hands, the bulb was placed on the floor and pressed with the foot With the pain and tactual stimuli, the pressure on the bulb was released immediately, but with the olfactory and auditory stimuli, pressure was not released until the termination of the stimulus application Thus a characteristic initial and final deflection in the stimulus line was made by which the duration of the stimulus could be checked

The infant was brought in from the nursery and placed on the stabilimeter platform, clad only in diaper and shirt, in the younger infants the navel was bandaged. A fresh strip of 3-inch bandage gauze was pinned about the abdomen, overlapping far enough at the ends to cover the pneumographic balloon, which was then pinned into place When the stabilimeter was used, the lever locking the apparatus was released, and the pens began to record The experimenter then recorded on the polygraph tape such data as the infant's name, sex, age, condition—dry, damp, wet, or soiled—and time. Then by means of activity symbols which were modifications of those used by Pratt (19), the experimenter kept a running account on the tape of the infant's behavior, with only brief interruptions for going around to the side to present a stimulus. Returning quickly to the polygraph tape, she recorded the response, if any, and marked on the respiratory line the approximate point at which the response had ceased. It may be objected that this was too much for any one person to do without missing portions of the behavior However, with a long preliminary practice, the experimenter developed a high degree of proficiency in recording responses quickly and concisely, and shifting position rapidly while keeping the infant in view Furthermore, for part of the experiment an additional observer was used to make annotations on the tape with the standardized symbols, while the experimenter remained beside the infant to apply the stimuli and keep a running record of her own. Later comparison of this record with that of the other observer revealed omissions of less than 1 per cent in her own record There were occasional variations in the description of a specific behavior item, such as "quick jerk of legs" versus "strong flexion of legs," but such variations could in no way affect the results in the light of the method of treating data

Stimuli were at all times presented by the same experimenter in order to assure the maximal constancy in their presentation. Stimuli were applied at approximately one-minute *intervals* *In Part 1, the* first portion of the investigation, only pain stimuli—needle-pricks on the big toe—were used In Part 2, pain, tactual, and olfactory stimuli were used, the first two types being applied at the various points previously stipulated The stimuli were presented in a random order In Part 3 auditory stimuli were used almost entirely, with only an occasional introduction of other types The two frequencies were usually alternated, but sometimes arranged in a less regular sequence.

Method of Handling Data The first important step was to decide upon the behavior patterns which might eventually be differentiated in terms of the extent or the duration of responses to stimuli in each condition

After numerous preliminary observations, the experimenter decided upon the group of categories given below in which nearly every possible behavior trend of the infant could be classified:

A. Generally quiet.
    1. *No eyelid or mouth movement*
        a Regular breathing.
        b Irregular breathing
    2. Eyelid movement
    3. Eyelid movement and mouth movement.
    4 Eyes open
    5. Eyes open and mouth movement.

B Occasional *stirs of body members*
    1. No eyelid or mouth movement
    2 Eyelid movement
    3 Eyelid and mouth movement
    4. Eyes open
    5. Eyes open and mouth movement

C Generally active
    1. No *eyelid or mouth movement*
    2 Eyelid movement
    3 Eyelid and mouth movement.
    4 Eyes open
    5 Eyes open and mouth movement

These conditions all refer to what has been noted in the one-minute period preceding stimulation

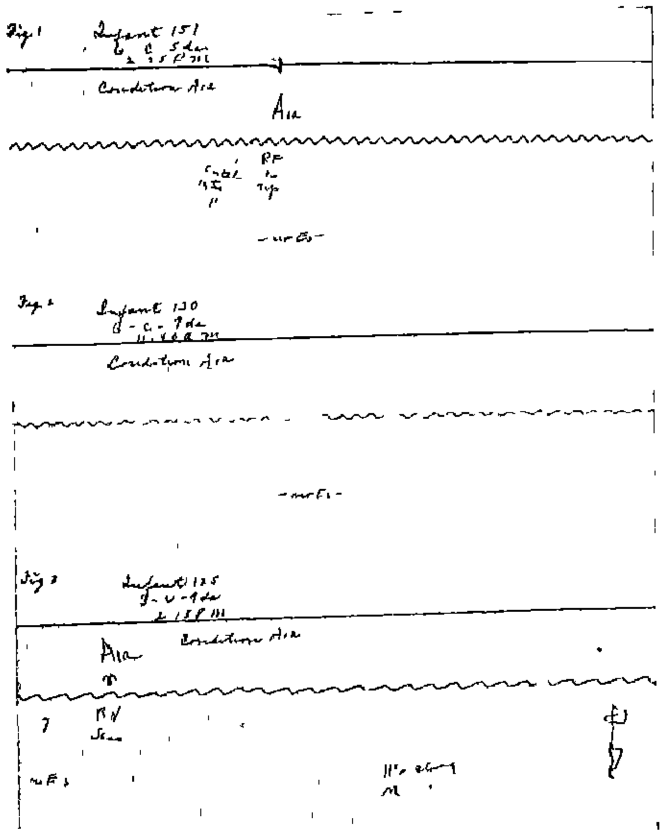
Condition *A* means that the infant has shown no body movement exclusive of facial responses for one minute preceding the presentation of the stimulus Condition *B* means that in the minute preceding the stimulus at least two discrete stirs of a body part, exclusive of facial responses, have been noted, e.g , flexion of left hand and extension of right leg Condition *C* means that at least one general body stir lasting more than five seconds has occurred during the minute preceding the stimulus application

Regular breathing may be determined by comparison with the types shown in Figures 1, 2, and 3. All other less regular types are classed as irregular; examples are found in Figures 4 to 12

The subdivisions are similarly interpreted "eyelid and mouth movement" indicates that at least two observations each of eyelid and of mouth movement have been recorded by the experimenter during the minute interval preceding the stimulus "Eyes open" means that the infant's eyes have been open almost continuously throughout the minute interval, and are still open at the moment of stimulation.

One additional point must be mentioned in connection with these classifications· Suppose that the minute period preceding stimulus *X* has been classed as B_2 During the minute following stimulus *X*, which precedes stimulus *Y*, only one stir of a body part is now noted instead of the minimal requirement of two The condition accompanying *Y*, then, is still called B_2, provided, of course, that the eyelid movement continues But if the interval following *Y* and preceding stimulus *Z* still reveals only one stir of a body member, with eyelid movement continuing, the condition is now called A_2. The same procedure is followed where eye and mouth movement are concerned. If only one eyelid movement had been noted preceding *Y* in the case above, the conditions would still have been called B_2, though the condition at *Z*, likewise with only one eyelid movement preceding it, would have been considered a B_1, provided the requisite number of body stirs continued Classification in terms of mouth movement was made in the same manner

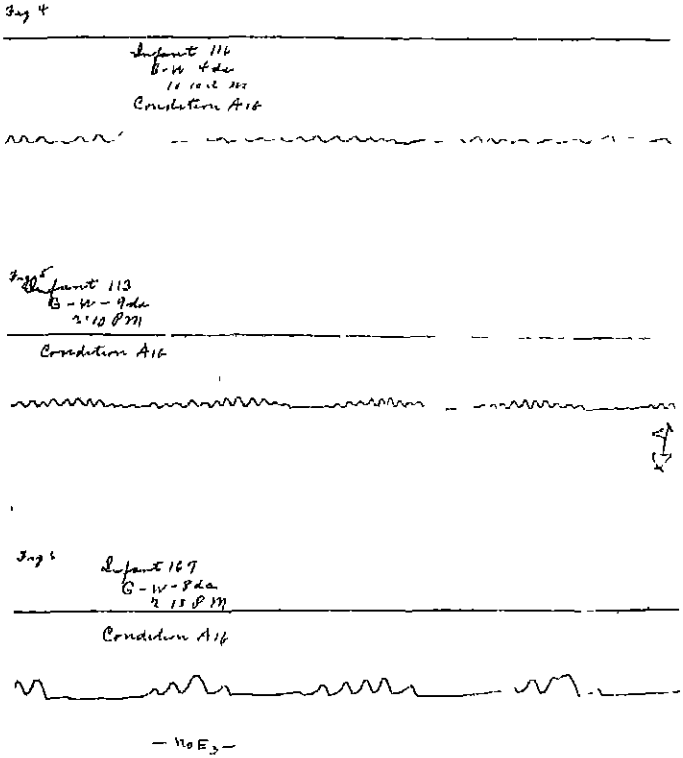
It may be asked why subdivisions for regular and irregular breathing were not made for *B* and *C* as well as *A* The experimenter did not note a single preliminary case where regular breathing, such as found in A_{1a} occurred in any of the other conditions for more



FIGURES 1-3
TYPES OF CURVES OF REGULAR BREATHING FOUND IN CONDITION A_{1a}

than a very short interval This initial observation was borne out in the final analysis of the entire group of data Moreover, any body movement beyond slight hand and foot stirs tends to distort the breathing curve. And since conditions *B* and *C* by definition include a certain amount of activity, the possibility of irregularity in the records is enhanced all the more

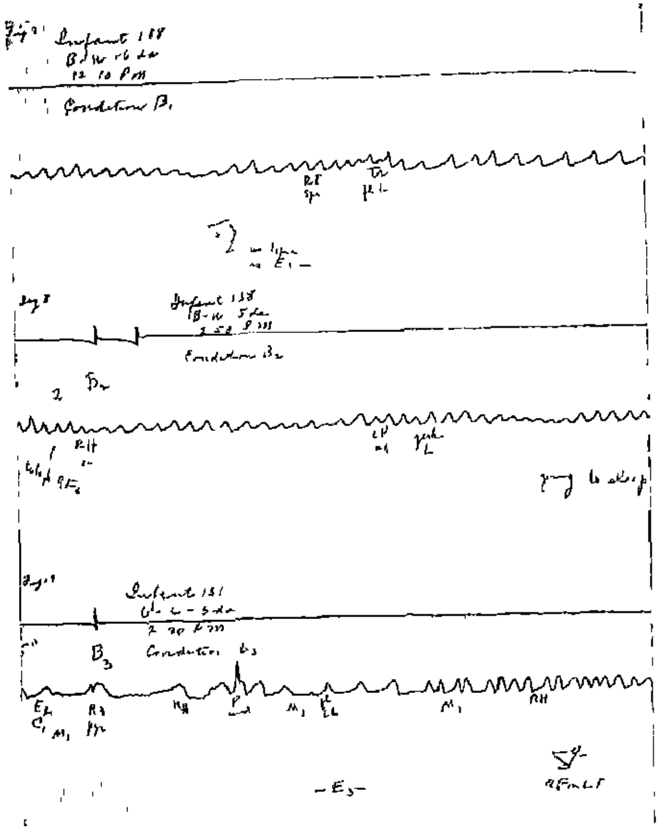
Also one might ask why there were no subdivisions under *A*, *B*, and *C* for mouth movement unaccompanied by eyelid movement



FIGURES 4-6
TYPES OF BREATHING FOUND IN CONDITION A_{1_b}

Again there were no preliminary cases where mouth movement occurred apart from eyelid movement Final analysis of the data revealed only 45 instances out of the 5342 stimulations where such a situation arose, in other words, only 8/10 of one per cent of the stimulations were accompanied by a condition in which mouth movement occurred without eyelid movement in the same minute interval.

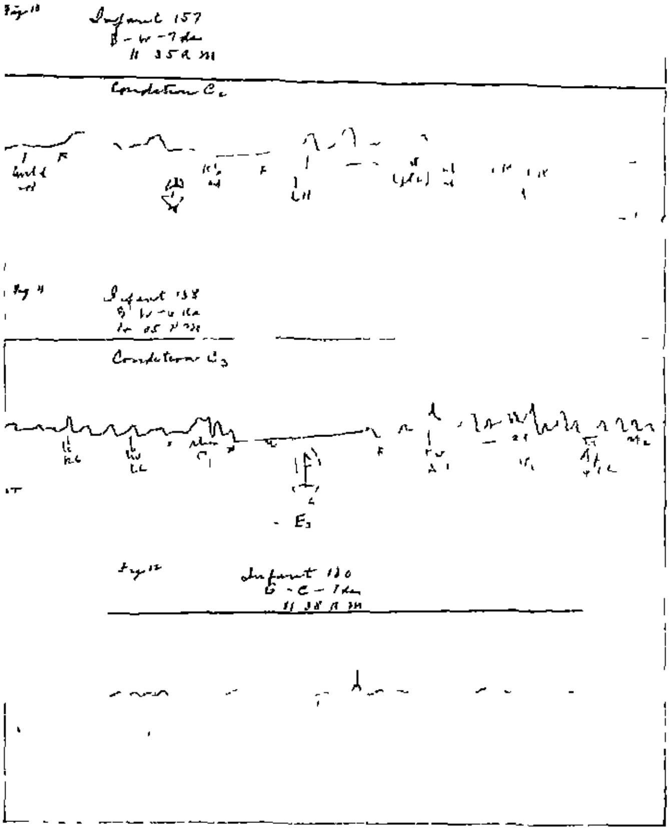
The choice of a one-minute interval was not a casual decision Continuous records in a preliminary investigation were obtained for



FIGURES 7-9

TYPES OF BREATHING CURVES FOUND IN *B* CONDITIONS

the period between feedings; behavior annotations were made on the polygraph tape, but no stimuli were applied. These records were scanned carefully in order to obtain the behavior classifications and also to choose an interval most sensitive to the type of behavior trends noted An interval of two minutes or longer would have obscured a brief change in trend, but an interval as short as 30 seconds, for example, would have emphasized these slight variations far too much A minute appeared to be about the length of time neces-



FIGURES 10-11

Two Types of Breathing Curves Found in *C* Conditions and One Illustration of an Isolated Deep Inspiration

sary to determine the particular behavior pattern existing before the presentation of a stimulus.

It must be remembered that the infant, at the exact moment when each stimulus was presented, was completely quiet, i e, there were no observable movements of body members, eyelids, or mouth, no matter what condition was defined by the preceding minute interval Only thus could we assume that movement occurring immediately after the presentation was a response to the stimulus and not merely a continuation of activity preceding it

The measurement of the duration of each response, in the absence of a time line, was performed as follows The speed of the moving tape was calibrated in order to measure the distance traveled in a ten-second interval This measurement agreed exactly with the distance indicated by the electromagnetic time line included in the earlier records. A celluloid ruler was then constructed, and divided into units corresponding to the ten-second intervals previously ascertained Measurements could then be made by placing the transparent ruler directly over the portion of the respiratory line which indicated a particular response

With the pain and tactual stimuli, measurements of the duration of the response were always made from the point when the stimulus was applied to the point where the termination of the response was marked, unless a slightly delayed response was definitely indicated in the experimenter's annotations With the stimuli of five-second duration—olfactory and auditory—measurements of the duration of the response were made from the point where the response actually began, as marked on the respiratory line. Of course, even here there were many cases where the response began with the initial application of the stimulus

If the response lasted more than 20 seconds, it was marked as 20+, and considered as 20 in the calculations. Inclusion of total measurements where some responses led to a long period of continuous activity would have distorted the records, blotting out significant trends in the data.

Where any response other than respiratory was noted, no attempt was made to include breathing changes in the measurement unless these changes were audible. As mentioned before, movement has a tendency to distort the breathing curve and produce a false respiratory record However, where no other response was noted, the breathing change was measured and included in the data. Such breathing changes could be noted easily only where the preceding breathing curve was fairly regular; when the breathing was generally irregular, the experimenter had to be very cautious in attributing any specific breathing irregularity, following the stimulus, to the stimulus itself. Such a decision was made only where the irregularity was quite unlike any of the irregularities in the respiratory curve during the preceding minute An early attempt was made to render this decision more objective by measuring with a microscope the *I/E* ratios of a series of respirations immediately preceding and immediately following the stimulus However, these *I/E* ratios were highly variable, and after struggling through several complex methods of comparing them the experimenter found that less information was procured in this way than by a careful inspection of the record Since no trend indicated by the laborious method could not also be ascertained with a fair degree of accuracy by inspection, and since in fact the *I/E* data furnished only a partial description, the laborious method was abandoned

In treating the data, questions arose concerning the utility of the stabilimeter records secured for half the trials in Part 2. A careful comparison of the stabilimeter records with the other data on the polygraph tape led to rejection of the stabilimeter data The reasons for rejection were as follows

(*a*). The stabilimeter is not sufficiently sensitive for the purposes of this investigation. Slight hand, foot, and facial movements, so important in this study, are not recorded by this type of apparatus.

(*b*) The stabilimeter is best adapted for recording gross motility, crying activity, or sudden, jerky movements In this study we are not interested in gross motility as such The stabilimeter hence tells us less about what we want to know than do the breathing curve and running annotations.

(*c*) The accuracy of the stabilimeter, as constructed in the earlier studies, is dubious Bilaterally symmetrical movements would tend to cancel each other. One end of the stabilimeter, by virtue of its construction, is much more sensitive than the other, and with the head of the infant habitually placed at that end, there is a tendency for the records to emphasize cephalic movements and underestimate caudal movements.

Disregarding the stabilimeter lines, then, the experimenter went through the records minutely, writing down at each point of stimulation the condition of the infant as determined by the preceding minute's activity, and the duration of the response For the records of Part 1 and Part 3, the data were tabulated according to the stimulus, the condition of the infant, the side stimulated (right or left), specific nature of response, duration of response, age, sex, and color For Part 2, the sex and color tabulations were omitted.

The age of the infant was tabulated thus birth to 24 hours, 0 days, 24 to 48 hours, 1 day, 48 to 72 hours, 2 days, etc. In other words, a 6-day-old infant in this classification was one experimented upon during the seventh day of its postnatal life. In Part 1, however, no 0-day classification was used; all infants up to 48 hours of age were placed in the 1 day group

While it is obvious that conditions can be compared in terms of the mean duration of a response in seconds, it is not so obvious that conditions can be compared in terms of extent of response It was at first thought possible to assign relative numerical values to responses, giving toe and finger movement, say, a value of 1, foot and hand movement a value of 2, leg and arm movement a value of 3, and so forth, in order to get a comparative numerical estimate for various types of responses But the difficulty of justifying such an arbitrary scheme became increasingly evident

Further difficulty arose in determining stages of "sleep depth" merely in terms of changing percentages of total-body movements Is a body jerk the equivalent of a general body stir? Both involve the entire body, but casual observation indicates that in some stages of apparently deepening "sleep" the body jerk or startle is a characteristic response A glance at the data indicates that the order of "sleep stages" would be quite different for the body jerks and general stirs, in some cases the order would be almost exactly reversed Next, considering "sleep depth" in terms of specific, localized responses, what responses should we consider typical of "deepest sleep"? Is a leg-only response the equivalent of an arm-only or head-only response? Is a mouth-only response the equivalent of toes-only? The same questions apply when evaluating responses in combination with other responses. You might suggest that we take each stimulus separately and determine "sleep depth" in terms of responses localized with reference to the specific stimulus used. But infant responses are generally not considered sufficiently localized with reference to a stimulus to justify such a procedure. For example, what comparative value would be assigned to a toe-flexion and a finger-flexion response to a toe-prick? Furthermore, what is a localized response with reference to an auditory stimulus? And should we expect the same degree of localization to an odor as to a needle-prick?

It seems, then, that the only way to establish "sleep depth" in terms of extent of response would be to rank conditions with reference to each type of response listed, such as no response, toes only, or leg plus, and to each type of stimulus used, and then find some way to *analyze this mass of data to determine any general agreement, if any,* as to the order of stages of "sleep depth."

Rather than resort to such a hopelessly complex method, the experimenter considered it preferable to determine stages in sleep depth in terms of duration of response and then note the trends in terms of extent of response throughout the stages thus ranked. In the tables of data for extent of response, then, the stages were arranged in the order determined in terms of duration of response. The per cent of occurrence of each type of response listed could be traced from stage to stage. Thus a careful survey would indicate whether the order of sleep stages seemed justified, though the primary purpose of such tables would not be justification so much as an inspection of general trends.

The following categories were used in these tables, no response, breathing change, toes, feet, legs, fingers, hands, arms, head, mouth, vocal, facial, eyelid, body jerk, general stir, and body jerk and stir. Except for the first, no response, and the last three more widespread responses, each item was listed according to whether the movement occurred alone or in combination with other responses, such as head only and head plus, mouth only and mouth plus.

Discussion of Results: I

Responses to Pain Stimuli. Examination of the data reveals that in terms of duration of response, in seconds, to a needle-prick on the big toe, the stages of decreasing depth of sleep are: A_{1_a}, A_{1_b}, B_2, A_2, B_1, C_1, A_3, C_2, B_3, C_3, C_4, B_4, C_5, and B_5. In other words, a quiet infant who breathes regularly and shows no eyelid or mouth movement (condition A_{1_a}) gives the shortest response to a needle-prick stimulus applied to the big toe. There was no instance of an A_5 condition. The largest number of cases were secured for A_{1_a}, A_{1_b}, B_2, and B_3, and the least for conditions in which eyes were open, with or without mouth movement.

The critical ratio for each successive two stages as given for this set of data is 6.79, 4.38, 1.08, 0.12, 1.36, 0.46, 0.07, 1.22, 2.57, 0.33, 0.21, and 0.05. The only sequences for which all successive stages are significantly different are A_{1_a}, A_{1_b}, B_2, B_3, and B_5 (6.79, 4.38, 5.77, 3.26), or A_{1_a}, A_{1_b}, B_2, C_2, and C_3 (6.79, 4.38, 4.36, 3.71). Stage

B_3 is not significantly different from either C_2 or C_3, and while C_2 is significantly different from B_5 (3.83) C_3 is not (1.91).

Mere inspection of the trend of time scores when classed according to age or sex or color shows that there is no consistent variation in terms of these variables. Regarding age differences, we find that while the responses in condition A_{1_a} are always shorter than in A_{1_b}, whatever the age group, there is no consistent increase or decrease in the length of response for either condition from one age group to another. The average response increases from 1.7 seconds at 1 day to 4.0 seconds at 2 days, decreases to 3.0 seconds at 3 days and to 2.2 seconds at 4 days, and then jumps up to 3.3 seconds at 5 days. Thereafter it decreases in the 6- and 7-day groups (2.4 and 1.2), rises slightly (to 1.6) at 8 days, and reaches 2.9 at 10 days; at 9 days there were too few data to compute a mean. The variation from day to day of the duration of response in condition A_{1_b} is also irregular, though not a duplicate of the variations of the A_{1_a} data. The day-by-day changes are as follows: increase, increase, decrease, decrease, decrease, increase, decrease, increase.

If we compare the results for conditions B_2 and B_3, we again find that there is the same B_2-B_3 sequence in every age group; that is, the responses in condition B_2 are always shorter than those in condition B_3. However, the degree of the difference is variable as is the length of response in either condition from one age group to another. The order of change in the B_2 stage is increase, decrease, increase, decrease, decrease, increase, increase, increase, decrease; in the B_3 stage the order is: increase, decrease, increase, decrease, increase, increase, no data, increase, decrease. While the order of change is similar the gross amount of the variation in seconds is not consistent (for B_2: +1.6, —1.9, +0.4, —0.2, +1.0, +0.6, +2.3, —2.5; for B_3: +7.5, —12.2, +4.3, —1.5, +0.6, +3.1, —, +0.9, —1.0).

Consideration of the color and sex data indicates that the response of the colored infant, as compared with that of the white infant, is longer in A_{1_a} and A_{1_b}, shorter in A_2 and A_3, longer in B_1, B_2, and B_3, shorter in B_4 and B_5, longer in C_1, and shorter in C_2, C_3, C_4, and C_5. The sequence of stages of sleep depth is the same only for A_{1_a}, A_{1_b}, A_2, B_3, and C_5.

Comparison of the data for male and female infants likewise reveals no definite sex difference. The response of a male infant is shorter than that of a female infant in conditions A_{1_a}, A_{1_b}, A_2, and A_3, longer in B_1, B_2, and B_3, equal in B_4, longer in B_5, shorter in C_1 and C_2, longer in C_3, shorter in C_4, and longer in C_5. The sequence of sleep stages coincides with respect to stages A_{1_a}, A_{1_b}, B_2, A_2, C_1, C_2, B_3, C_3, and C_5. It is noticeable that the chief disagreements in sequences for sex and color center around those stages for which we have the least data, and hence cannot be considered significant.

The lack of consistent variation in terms of such variables is not surprising in view of the findings of previous investigators, who in general ascertained no significant color or sex differences in infants, and only doubtful age differences. Color as such is hardly a logical differentiation, because of the extremely variable percentages of white blood in the infants designated as colored. The possibility of age differences seems rather slight when we consider the fact that even so-called normal, full-term infants may differ in age as much as the number of days in the age span studied here. With this much difference in prenatal age, we should hardly expect consistent day-by-day alteration in the responses of a group of infants classed only with reference to postnatal age. What we can do is to compare the youngest infants, say, 0, 1, and 2 days of age, with the oldest infants, say, 8, 9, and 10 days of age. This would allow for some variation in prenatal age. Such a comparison here reveals a slight tendency for the responses of the older infants to be of greater duration, save in the A_{1_a} stage of motility. One might interpret this on the one hand to mean greater sensitivity with increasing age save in conditions of least motility. Or one might say that the motility stages keep about the same order with increasing age but that the responses are longer except in conditions of least motility, where the responses are even shorter than during the first few days after birth.

Our next consideration is the second factor, extent of response. The data were tabulated to show the percentage of instances in which any specific response occurred, either alone (as toes only) or in combination with some other kind of movement (as toes plus). The conditions were arranged in the order of decreasing duration of response. The tabulated data indicated, for example, that in condition A_{1_a} there were 324 instances when the infants were pricked with a needle on the toe, in 21.9 per cent of these instances there was no response, of 260 cases of stimulus application in condition A_{1_b}, there was no response in 10.0 per cent of the instances, of 145 stimulus applications in condition B_2, 6.9 per cent of the cases resulted in no observable response. Going back to the A_{1_a} condition, we can see that in 0.6 per cent of the 324 stimulus presentations, the response consisted of a breathing change alone—a deep inspiration, or an obvious change in amplitude or frequency. In 4.9 per cent of the 324 presentations, a breathing change occurred in combination with some other form of activity. In 4.0 per cent of the total number of stimulus presentations in condition A_{1_a} the response consisted of toe movements alone, but in no instance did specific toe movement occur in connection with some other type of response. The other figures could be read similarly.

We find a steady decrease in the number of cases where no response occurs as we go from conditions of least motility to conditions of greater motility, save for conditions B_1 and C_1, that is, the per cent of cases where no response occurs is 21.9 in A_{1_a}, 10.0 in A_{1_b}, 6.9 in B_2, 5.4 in A_2, 4.2 in A_3, 1.3 in C_2, and 1.0 in B_3, but in conditions C_3, C_1, B_1, C_5, and B_5 there are no instances at all where a stimulus fails to elicit a response. Toe movements in general decrease, a response of toes only is observed in 4.0 per cent of the cases in A_{1_a}, 1.5 per cent in A_{1_b}, and 2.3 per cent in A_2, but never occurs in the other conditions; a toe-plus response occurs in 0.4 per cent of the cases in A_{1_b} and 3.7 per cent in B_1, but in none of the other cases.

Continuing our analysis in this fashion, we find a steady decrease in no-responses and in specific, localized responses like toes only, feet only, and legs only, though the decrease is not always regular, the chief irregularities occurring in intermediate stages like A_3, B_1, and C_1 for which fewer cases are cited. The per cent of body jerks varies in an irregular fashion, but there is a marked increase in the number of general stirs as responses in conditions of greater motility, besides a tendency for body jerks plus general stirs to increase, though this increase is somewhat irregular; in other words, there is less likelihood that a body jerk will be followed by a general stir when the infant is generally quiet than when it manifests more activity. Eyelid movement appears more frequently, although none is recorded for conditions C_4, C_5, and B_5. This may be due, on the one hand, to the small number of cases, and on the other hand to the fact that the eyes are already open in these conditions, and hence specific eye movements would not be noted so readily.

Vocal, mouth, and facial concomitants increase in those conditions of greater motility. Though legs-only movements decrease somewhat, leg movements in combination with other movements increase, though with great irregularity. While the per cent of head-plus movements does *not vary consistently, there is in no stage of sleep depth a* head response alone, and only occasional responses of toes-plus, fingers-only, or plus, hands-only, arms-only, mouth-only, facial-only, or vocal-only.

In general, then, whatever the condition, specific, localized responses tend to be replaced by more complex patterns of response with cephalad components as the infant becomes more active.

It is not surprising that so many body jerks are found in the A_{1_a} and A_{1_b} groups. In the newborn as in the adult, what appears to be a process of falling asleep or at least sinking into deeper sleep is frequently *characterized by body jerks or startles. This is not true of* what appears to be a waking-up process. The body jerks, while still frequent in the stages of greater activity, were observed to be of greater duration than those in A_{1_a} and A_{1_b}, and often were followed by general stirs; this difference in the length of the body jerk is hence emphasized more in a *duration* tabulation than in an *extent* tabulation.

It should also be noted here that the per cents of body jerks found in the various sets of data are often the result of a few individual cases where the typical reaction was a body jerk; in other words, some infants seemed somewhat tense and "jumpy" even in conditions A_{1_a} and A_{1_b}.

DISCUSSION OF RESULTS. II

Responses to pain, tactual, and olfactory stimuli. Inspection of the data gives us many interesting facts concerning the duration of response to pain, tactual, and olfactory stimuli. As there are only two instances of an A_4 condition, none of A_5, five of B_4, nine of B_5, three of C_4, and five of C_5, these conditions cannot be compared with the others.

The data are interpreted thus: Brush—foot—1.5 in A_{1_a} means that the response of an infant in this group to the stroking of the sole of the foot with a camel's-hair brush lasts on the average 1.5 seconds when the infant has been quiet, with no eyelid or mouth movement, and breathing regularly for one minute before the stimulus is applied. Brush-total—2.9 in A_2 indicates that the average duration of the infants' responses to brush stimuli as a whole is 2.9 seconds when the infant has been quiet, with only eyelid movement, for one minute before the stimulus presentation. The remainder of the data are interpreted similarly

For any type of stimulus, then, we can rank these various conditions as stages of decreasing sleep depth, placing first on the list the condition in which the response is shortest, for in terms of our criterion this represents the deepest sleep with reference to the stimulus under consideration, For example, for a foot-brush stimulus, the stages of sleep depth, ranked from deepest to lightest sleep, are: A_{1_a} A_2, A_{1_b} and A_3, B_1, B_2, C_3, B_3, C_2, and C_5

TABLE 2

Pain	Tactual	Odor	All
A_{1_a}	A_{1_a}	A_{1_a}	A_{1_a}
B_1	A_{1_b}	A_{1_b}	B_1
A_3	A_3	B_1	A_{1_b}
A_{1_b}	B_1	A_3	A_3
A_2	A_2	A_2	A_2
B_2	B_2	B_2	B_2
C_2	C_2	C_2	C_2
C_3	C_3	C_3	C_3
C_5	C_5	C_1	C_5
			C_1

The critical ratios for each two successive stages in Part 2 are as follows: 2.17, 0.16, 0.53, 1.85, 0.58, 2 18, 1.75, 1 09, 1.70, 0 88 The only sequences in which each stage is significantly different from the succeeding one are: A_{1_a}, A_{1_b}, A_2, G_2, C_4 (4 23, 4 23, 3.06, 3 04) and A_{1_a}, A_{1_b}, B_2, C_2, and C_4 (4.23, 7.35, 2 98, 3.04). Stage B_3 is almost eligible for each sequence; the critical ratio for A_2 and B_3 is 2 19, for B_2 and B_3, 2.18, and for C_2 and B_3, 1 75

Responses in any condition are longer for toe-needle, lip-brush, and nostril-brush stimuli. We may say that these areas are most sensitive, or that the infant's sleep in any stage is less deep with respect to these stimuli than to the others in the group Furthermore, the responses to the tactual stimuli as a whole are shorter than to either needle or olfactory stimuli in any condition save that of deepest sleep

However, in spite of these variations, it is interesting to note that the order of the stages is fairly constant from one type of stimulus to another, save for conditions B_1 and A_3. Responses in condition A_{1_a} are always shorter than in A_{1_b} except for the hand-brush, nostril-brush, violet, and lemon stimuli, but the differences are too slight to be reflected in the totals for each group of stimuli. A_{1_b} responses are always shorter than A_2 responses with needle and odor stimuli, though inversion occurs with three of the brush stimuli. However, A_{1_b} responses are always shorter than B_2 responses, whatever stimulus is used. The number of inversions of the sequence previously given for all the stimuli combined are, A_2 and B_2—7 (for 7 stimuli the response in condition A_2 is longer than in condition B_2), B_2 and B_3—5, B_3 and C_2—2; C_2 and C_3—2. There are insufficient data to compare C_3 and C_5. It must be remembered that many of these variations are traceable to the small number of cases from which a mean is computed.

With these data as with those in Part I, there are no consistent variations apparent when tabulations are made according to age, even when the 0-, 1-, and 2-day groups are compared with the 8-, 9-, and 10-day groups. For example, let us compare conditions A_{1_a} and A_{1_b} with reference to brush stimuli. At 0 days, the response in condition A_{1_a} is shorter than in A_{1_b}; at 1 and 2 days, the A_{1_a} response is longer, at 3 days it is equal in length to the A_{1_b} response, at 4 and 5 days it is again shorter, and at 6 days equal. At 7 days there are too few data for a comparison. At 8 days the A_{1_a} response is longer, at 9 days shorter, and at 10 days, again longer than the response in condition A_{1_b}. It is obvious that no consistent variation in terms of age exists in the relationship of the A_{1_a} and A_{1_b} stages when brush stimuli are used. Nor is there any consistent variation from one day to another in the mean duration of response in either condition considered alone. In the A_{1_a} condition, the average length of response increases from 2.0 to 2.1 to 2.3 seconds in 0-, 1-, and 2-day groups, but decreases to 2.0 seconds again at 3 days and to 1.6 seconds at 4 days. At 5 days it rises slightly, to 1.8, and then drops back to 1.5 in the 6- and 7-day groups. The duration jumps up to 2.8 at 8 days, drops back to 1.9 at 9 days, and finally rises to 3.0 at 10 days. A similar analysis of the remainder of the data reveals the same lack of consistent varition, whether one considers the sequence of conditions from one age group to another or the variation in length of response from one age group to another in the same condition.

Turning now to a comparison of results where the three youngest and the three oldest age groups are combined respectively, we likewise find no consistent variation. The older groups have a longer response to brush, needle, and odor stimuli than the younger in condition A_{1_a}, shorter in A_{1_b}, longer in A_2, shorter in B_2, and longer in B_3. The A_{1_a}-A_{1_b} sequence is reversed in the older groups, but the difference is very slight, the B_2 and B_3 sequence is constant, but the A_2 stage precedes A_{1_a} in the youngest group, and follows B_2 in the oldest groups. Since these positions are not a true reflection of the variations apparent in the data for individual stimuli, we cannot accept them as representative of true age differences.

An additional measure is included here—the number of stimuli required to elicit a response. This measure, of course, is applicable only to the pain and tactual stimuli, which alone were summated. Again we find the toe, lip, and nostril "most sensitive"; that is, in any condition the fewest stimuli were required to elicit a response when these areas were stimulated. The rank-order of conditions here is given in Table 3.

TABLE 3

Needle	Brush	Both
B_1	A_{1_b}	A_{1_b}
A_{1_a}	A_{1_a}	A_{1_a}
A_3	A_3	A_3
A_{1_b}	B_2	B_1
A_2	C_3	B_2
B_2	A_2	A_2
B_3	B_1	B_3
C_3	B_3	C_3
C_2	C_2	C_2
C_5	C_5	C_5

We also note some slight disagreement with the classifications previously cited. Though the A_1 groups again come first, the A_{1_b} condition requires more stimuli to elicit a response to tactual stimuli than does the A_{1_a} condition. The relative position of the B_2 and B_3 conditions is the same. The C_2 and C_5 conditions for both pain and tactual stimuli require the fewest number of stimuli to elicit a response, but with tactual stimuli the C_3 stage precedes the B_3 stage. Just as in the duration-of-response classification, the B_1, A_2, and A_3 conditions are quite variable in their relative positions.

In the extent-of-response tabulations for Part 2 the pain and tactual stimuli were grouped as follows: (*a*) head stimuli—cheek-needle, cheek-brush, lower-lip-brush, nostril-brush, (*b*) arm and hand stimuli—arm-needle, hand-needle, hand-brush, (*c*) leg and foot stimuli—leg-needle, foot-brush, toe-needle. The data were grouped thus in order not to obscure the existence of specific types of localized responses, since examination of the data revealed that there is some tendency for localized responses, *when they occur, to occur close to the region of stimulation* The olfactory stimuli were of course grouped together

The responses to pain and tactual stimuli are classified according to extent of response regardless of the number of stimuli required for eliciting the response There are not sufficient data to classify them specifically according to the number of stimuli required. In the no-response category we have the per cent of instances where more than one stimulus was necessary

With stimuli applied to portions of the face, responses show trends similar to those in Part 1 Repetition of stimuli to produce a response becomes less frequent as general motility increases The per cent of breathing changes decreases from condition A_{1_a} to conditions of greater motility as a component of the response save in A_3 and C_3. Arm, head, and mouth responses in combination are generally frequent in any condition, although there are fewer mouth components in responses in conditions A_{1_a}, A_{1_b} and B_1, than in any other condition, save C_5, where, however, there is a total of only 6 cases Nevertheless, facial, vocal, and eyelid components increase as the infant becomes more active Leg responses are about the same, but the per cent is consistently less than that of arm and head responses There are generally few highly specific responses such as toe and finger movements and mouth or vocal responses occurring alone. The lack of specific, localized response is especially marked in the C conditions, in C_2, C_3, and C_5 there are no responses such as breathing-change-only, toe or finger movements, movements of feet alone, or of vocal, facial, or eyelid response alone In general, body-jerk responses decrease as motility increases, while general-stir responses increase There is also a slight tendency, as in Part I, for body jerks to be followed immediately by general stirs

The data obtained from stimulation of the arm and hand show only slight variations from the above trends. Leg responses in all conditions are still about the same, but are only slightly less frequent now than arm movements. Head responses, especially in combination, are less frequent and decrease in conditions of greater motility, except in condition C_2; here, however, this merely indicates 1 out of 7 cases Mouth movements seldom occur in conditions A_{1_a} or A_{1_b} in this group of data, and increase somewhat in the other conditions, as do vocal, facial, and eyelid components. Finger-movement responses are more noticeable in most conditions than for head stimuli, and when occurring alone decrease somewhat as the infant becomes more active

In the data obtained from stimulation of the leg and foot, we find toe, foot, and leg responses quite prominant, arm movement less frequent, and finger, hand, and head movement seldom occurring. As general motility increases, toe-movement responses decrease, except for an increase in toe-plus movements in conditions C_3 and C_5. Movements of feet only are in every condition less frequent than foot movements in combination, just as leg-plus movements are always more frequent than leg-only responses. All the foot and leg responses, however, vary irregularly from one condition to another save leg-plus responses, which definitely increase as the infant becomes more active. Arm-plus movements tend to increase, though less regularly Again mouth, vocal, facial, and eyelid responses appear more frequently in response patterns with increasing general motility. As before, body jerks tend to decrease, and general stirs tend to increase, though body jerks plus stirs vary in no definite manner.

The occasional appearance of a zero in only one of the C stages with respect to one type of response may possibly be attributed to a chance factor operating with a small number of cases

With olfactory stimuli, there is a rapid decrease in no-responses as the infant becomes more active but no pronounced order of decrease in breathing-changes-only. On the other hand, there is an increase in foot responses, and in leg, hand, arm, and head movements in combination Head-only responses show no consistent variation, but mouth, facial, vocal, and eyelid components become more frequent as general activity increases, with only slight irregularities. As with the other stimuli, body jerks tend to decrease and stirs to increase

In general, then, the extent of response to the stimuli in Part 2 shows the following trends: (a) decrease in the number of no-responses or repeated stimulations as the *infant becomes more active*, (*b*) decrease in the number of specific, localized responses, (*c*) increase in variability and extent of response, with a parallel increase in mouth, facial, vocal, and eyelid components, and (*d*) decrease in number of body jerks, with an increase in the number of general stirs

DISCUSSION OF RESULTS: III

Responses to Auditory Stimuli In this section of the investigation only auditory stimuli were used, the frequencies were 256 and 2048 cycles per second, and the corresponding intensities 22 and 24 dynes per square centimeter respectively

The stages of motility with reference to auditory stimuli, in terms of duration of response, are arranged in Table 4

TABLE 4

256	2048	Both
A_{1_a}	A_{1_a}	A_{1_a}
A_{1_b}	A_{1_b}	A_{1_b}
A_2	B_1	B_1
B_1	A_2	A_2
A_3	B_2	B_2
B_2	A_3	A_3
C_2	C_2	C_2
C_3	B_3	C_3
B_3	C_3	B_3
B_5	B_5	B_5
B_4	B_4	B_4
C_5	C_5	C_5

There were no A_5 or C_1 conditions, and too few of A_4 and C_4 to include The largest number of stimulations occurred in conditions A_{1_a}, A_{1_b}, B_2, and B_3, with somewhat fewer in A_2, and even less in B_1, A_3, C_2, and C_3. It is interesting to note that the conditions most variable in their position are those less frequently found in the newborn infant These classifications agree with those of Parts 1 and 2, uncorrected for significant differences, with respect to this order at least: A_{1_a}, A_{1_b}, B_2, B_3, and C_5 The one outstanding variation with auditory data is in the relative position of B_3 and the C_2 and C_3 stages It may be that in these moderate stages of general activity an auditory stimulus has a quieting effect greater than in a B_3 condition, however, while this would explain the results for a 256 frequency, it would not explain the order of motility stages for a 2048 frequency, where C_2 follows and C_3 precedes the B_3 stage. Totals for both sets of data, however, place the C_2 and C_3 stages before the B_3 stage. Our only alternative is to say merely that an infant generally gives shorter responses to auditory stimuli in conditions C_2 and C_3 than in condition B_3. However, B_3 is not significantly different from C_2 and C_3 (0.88 and 0.23).

The critical ratio for each successive two stages of the total data in Part 3 is: 6.38, 2.75, 1.52, 1.63, 0.14, 1.61, 0.79, 0.88, 1.66, 0.07, 0.60. A determination of other possible combinations reveals that only the following sequences are significant: A_{1_a}, A_{1_b}, A_2, B_3, C_5 (6.38, 6.69, 7.61, 4.69), A_{1_a}, A_{1_b}, A_3, B_3, C_5 (6.38, 4.84, 3.80, 4.69); or A_{1_a}, A_{1_b}, B_2, B_3, C_5 (6.38, 9.70, 6.36, 4.69). Stages A_2, A_3, and B_2 are not significantly different from one another (A_2-A_3, 1.13, A_3-B_2, 0.14, A_2-B_2, 1.63).

Considering only those sequences which are significantly different, the sequences of Parts 1, 2 and 3 which are most similar are: Part 1—A_{1_a}, A_{1_b}, B_2, B_3, C_5; Part 2—A_{1_a}, A_{1_b}, B_2, C_2, and C_1; Part 3—A_{1_a}, A_{1_b}, B_2, B_3, C_5. The sequences disagree with regard to the last two stages in each, but there is no actual contradiction. Variation in the number of cases for each condition rather than differential stimulus effects may account for the discrepancy.

Note also that stages B_5, and B_4, in spite of the small number of cases where these conditions occurred, give responses consistently longer than those in any other condition except C_5, in which responses to all stimuli are of greatest duration. This is in accord with casual observations that infants with eyes open are "awake," especially when they are active as well.

In every condition except C_2 the response to the lower frequency is longer than to the higher frequency. This is in accordance with Stubbs' (22) statement that sleeping infants respond "better" at lower than at higher pitches.

Classification of the data according to sex and color shows no significant trends. Classification according to age shows no consistent variations unless one compares, as before, the 0-, 1-, and 2-day data with that for 8, 9, and 10 days. Even here the only indication is that in the A_1 stages the responses of older infants are generally shorter than those of the younger; that is, the mean responses in conditions A_{1_a} and A_{1_b} are shorter (0.5 and 1.4 seconds) for the older infants than for the younger (0.7 and 1.7 seconds), though the reverse is true for the B_2 and B_3 groups, and variable for the other stages.

Considering the extent of response, we find a rapid decrease in *no-responses as general motility increases, and a similar* but less marked decrease in breathing-changes-only. Toe movements are infrequent in any condition, but as activity increases, there is a decided increase in responses such as foot, leg, finger, hand, arm, and head movements in combination. There is an enormous increase in mouth, facial, vocal, and eyelid movements as components of more widespread responses. For example, mouth movements increase from 0.6 per cent in A_{1_a} to 4.7 per cent in C_5; vocal responses from 0 to 7.1 per cent (10.7 per cent in B_8), facial movements from 0 to 28.6 per cent; and eyelid movements from 0.9 per cent to 38.1 per cent. Body jerks do not occur frequently in any condition, while general stirs show a marked increase—from 0.3 per cent in A_{1_a} to 38.5 per cent in B_5—but drop back to 2.4 per cent in C_5. Leg and arm responses, in any condition, exceed the more specific finger, toe, hand, and foot responses, though leg movements in combination occur more frequently than arm-plus movements in any condition. The trends in general are similar to those in Parts 1 and 2, save that there is no marked difference here from conditions of least to greater motility in terms of specific, localized responses. There is, if anything, a slight increase in specific responses of toes, feet, fingers, and hands, to auditory stimuli as general motility increases.

TOTAL DATA

Taking the data as a whole, we find that in terms of duration of response, the stages of sleep depth are A_{1_a}, A_{1_b}, B_1, A_3, A_2, B_2, B_3, C_2, C_3, B_4, B_5, and C_5. The critical ratios for each two successive stages is: 8.63, 5.12, 3.57, 0.34, 0.32, 7.19, 3.44, 2.30, 1.15, 0.23, and 0.59. The only sequences where each stage is significantly different from the next, are shown in Table 5.

Conditions A_2, A_3, and B_2, while significantly different from the

TABLE 5

CRITICAL RATIOS BETWEEN SUCCESSIVE STAGES OF MOTILITY

Sequence	Critical Ratios	Sequence	Critical Ratios
A_{1_a}	8.63	A_{1_a}	8 63
	5 12		5 12
A_{1_b}	3 19, 3 57, 3 97	A_{1_b}	3 19, 3 57, 3 97
	6.61, 8.21, 7.19		6 61, 8 21, 7 19
B_1		B_1	
	3 44, 3 83		3 04, 3.39
A_2-A_3-B_2		A_2-A_3-B_2	
	4 48, 3 39		
B_3		B_3	
C_2-C_3		B_4-B_5	
C_5			

preceding and succeeding stages, are not significantly different from each other (A_2-A_3, 0 34; A_3-B_2, 0.82, A_2-B_3, 0 32). Likewise C_2 and C_3 (2 30) and B_4 and B_5 (0 23) are not significantly different. However, it may be possible to get a single composite sequence by combining C_5 with B_4 and B_5 We find the mean thus obtained is significantly different from those for C_2 and C_3 (7.03 and 3 67). In other words, the fact that C_5, B_4, and B_5 are not significantly different from each other but are significantly different when combined, can be interpreted to mean that when the eyes are open no differential depths of sleep can be determined, and mouth movement is not a determining factor as in the B_2 and B_3 stages Sleep is lighter, or the infant is more awake, in these stages than in any condition where the eyes are closed, whatever the activity concomitants.

Therefore we can adopt this sequence of total results:

A_{1_a}
A_{1_b}
B_1
A_2-A_3-B_2
B_3
C_2-C_3
$(C_5+B_4+B_5)$

This sequence compares favorably with those found for Parts 1, 2, and 3 separately:

Part 1	*Part* 2	*Part* 3
A_{1_a}	A_{1_a}	A_{1_a}
A_{1_b}	A_{1_b}	A_{1_b}
B_2	A_2-B_2	A_2-A_3-B_2
C_2-B_3	C_2	B_3
C_3-C_5	C_4	C_5

Variations from the sequence of total results consist primarily of the omission of stages, possibly due to lack of sufficient data for the stages omitted or to lack of significance of these criteria. The only variation which may be a function of the stimulus used is the determination of a significant difference between conditions C_2 and C_3 in Part 1.

Descriptively *the sequence for the total data means that an infant* "deepest asleep" is generally quiet, shows no eyelid or mouth movement, and breathes regularly. As its "sleep" becomes less deep, the breathing loses its regularity. Slight stirs of body members may then appear, followed later by eyelid movement and then mouth movement as well. Or, in another infant, eyelid movement and mouth movement may appear before the stirs of body members are observed. While such stirs continue, the infant becomes more active, the eyes finally open, and mouth movement again appears. The order of these stages is the exact opposite if we are considering the process of "deepening sleep."

The specific sequence of stages for any one child may vary slightly in that some of the stages may be skipped. One infant, for example, may in waking follow the sequence $A1_a$, $A1_b$, A_2, B_2, B_3, C_3, and C_5; another may follow the sequence $A1_a$, $A1_b$, B_1, B_2, C_2, B_4, and B_5, with slight fluctuations back and forth throughout the process of waking up. The actual stages observed may not be exactly the same for the going-to-sleep and the waking-up processes in the same infant, again because different stages may be skipped.

Glancing back over the total data we also find consistent trends for the extent of the response throughout the motility stages. As general motility increases, there is a steady decrease in no-responses, with a corresponding increase in widespread, variable responses with mouth, vocal, facial, and eyelid components.

With regard to specific, localized responses, however, the change from one stage to another seems to depend upon the type of stimulus used. This fact may be explained with reference to a tabulation in which is given the per cent of cases in which each response occurs in condition $A1_a$ only, to the stimuli used in Parts 1, 2, and 3. With auditory stimuli, Part 3, the tendency for specific, localized responses to increase as the infant becomes more active may be due, partially at least, to the fact that there are few responses of any sort to an auditory stimulus in conditions of least motility, somewhat more to an olfactory stimulus, and even more to tactual or pain stimuli, the movements which do occur seem to depend upon the point of application, especially with tactual and pain stimuli. For example, no response occurs in A_{1_a} in 71.8 per cent of the cases with an auditory stimulus, 64.4 per cent with an odor; 47.9 per cent with arm and hand stimuli; 31.7 per cent with head stimuli; 25.5 per cent with leg and foot stimuli, and only 21.9 per cent with a needle-prick alone. Likewise the responses of breathing-change-only range thus: 16.4, 5.9, 0.7, 1.4, 0, and 0.6 per cent. Breathing-change-plus responses vary almost inversely—0.3, 9.6, 14.1, 19.3, 6.1, and 4.9 per cent, the last two percentages referring to stimulation of the caudal portion of the infant. Similar analysis can be made of every other item. The most frequent occurrence of any type of response to auditory stimuli in A_{1_a} is for leg-plus—3.0 per cent—but for the the other groups the per cents are 5.9, 29.6, 18.6, 17.0, and 14.5. The next most frequent response in Part 3 is arms-plus—2.7 per cent—but the other groups give 6.7, 31.7, 22.1, 5.3, and 6.5 per cent. Again the last two figures refer to caudal stimulations, where we would not expect localization of response in the head end, but even here the per cents are larger than for auditory stimuli. Note also the increasing per cents of body jerks—0.6, 6.7, 12.7, 14.5, *6.5, and 17.3—and of general stirs—0.3, 6.7, 6.3, 13.8, 5.3 and 3.1* —where the first per cent refers to Part 3, the next to odors, and so forth. While the per cents of mouth and eyelid components are not least for auditory, the per cents are small for any type of stimuli in condition A_{1_a}. In general, then, fewer body movements of any sort occur to auditory stimuli than to any of the other stimuli used in this study. Hence, along with increasing complexity and extent of the response, it is not surprising that we find a slight concomitant increase in specific movements in Part 3.

We may reach the same conclusion by considering the data in a similar tabulation for condition A_{1_b}. Again we find that the per cents of no-responses, breathing-changes-only, and of larger body movements like body jerks, general stirs, and foot, leg, and arm responses are least frequent for auditory stimuli, while only small per cents of more specific movements occur, regardless of the fact that they may be slightly larger than for other stimuli which elicit highly localized responses.

For the data as a whole, among the total-body movements the body-jerk responses, considered typical of "going to sleep," decrease as the infant becomes more active, while general body stirs, longer and slower than body jerks in the sequence of movements, increase.

General Discussion

Let us consider now the adequacy of the sleep criteria used previously for infants. Marquis' (16) criterion of "eyes closed for one minute" could be A_{1_a}, A_{1_b}, A_2, A_3, B_1, B_2, B_3, C_1, C_2, or C_3. Pratt, Nelson, and Sun's (19) criterion of "eyes closed" could include any of these stages as well as conditions of violent activity and crying, besides momentary instances of eye closure in stages B_4, B_5, C_4, and C_5. Irwin's (11) criterion, "eyes closed and quiet," could include A_{1_a}, A_{1_b}, A_2, and A_3, and possibly B_1, B_2, and B_3 where the stirs of body members are very slight; it could also include short quiet intervals in the C_1, C_2, and C_3 stages. Disher's (7) and Taylor's (23) criterion, "eyes closed and no observable skeletal movement," could include A_{1_a} and A_{1_b} at least, and possibly short intervals in any of the other stages unless the criterion specified the length of the period to which this criterion applied. Dockeray and Rice's (8) criterion, "quiet for one minute preceding stimulus," could include A_{1_a}, A_{1_b}, A_2, A_2, and possibly B_1, B_2, and B_3 if the stirs were very slight. Even with the most generous interpretation, eliminating the possibility of chance moments of quiescence in lighter sleep, the most adequate criterion, that of Disher, includes both the A_{1_a} and A_{1_b} stages. Thus we see that no one of these criteria accurately identified the condition of "sleep" referred to in the investigation. And since the present results indicate definite changes in the nature and extent, as well as duration, of infant responses from one stage to another, it is obviously difficult, if not impossible, to compare and evaluate the various findings reported.

A few additional comments should be made concerning the results as a whole.

Numerous interesting factors concerned with respiration in the newborn infant have arisen in this study. There is no indication here to bear out Cramaussel's (3) description of breathing in the sleeping newborn. His youngest subject was 15 days old. He concluded from the breathing curves for this subject when "asleep" that external stimuli affect the curve very little. We have presented data showing numerous instances of such effects. Furthermore, he found the inspiration hesitant, arrested midway, and rather slow, while the expiration is direct and rapid. This type of breathing is found here and there in our records, but is by no means typical of the entire group of infants or even of the same infant from one condition of sleep to another. Cramaussel also found sharp angles instead of smooth half-circles, and extended, tremulous plateaus. While in Figure 1 we do have an example of such "sharp angles," it is the exception rather than the rule, for the smooth undulations in Figures 2 and 3 are found more frequently. But Cramaussel declared that breathing does not become regular until the age of 1½ months at least. It is quite likely that he did not observe enough infants, or even any one infant long enough; his 15-day-old subject probably did not happen to be observed in any A_{1a} condition; he gave no criterion of sleep, and hence could have been observing the infant in stage A_{1b}, A_2, A_3, B_1, B_2, or B_3. Examination of the groups of figures will give some idea of the great variation in respiratory curves from one condition to another.

Another interesting feature of the infant's respiration is its occasional periodicity, two forms of which are shown in Figures 5 and 6. This periodicity is known as Cheyne-Stokes breathing when found in the adult. Howell's (10) description of this type of breathing fits Figure 5 fairly well; he stated that this breathing occurs in groups of 10 or 30, separated by intervals equal to 30 or 40 respiratory movements. However, this would make the intervals between groups longer proportionately than in Figure 5. Wright's (25) description of the Cheyne-Stokes breathing as periodic breathing, variable in form, could include less rhythmical types of periodicity than that illustrated by Howell, and therefore would include Figure 6.

While pathological conditions, the dorsal position, and the condition of sleep are variously assigned by physiologists as causes of Cheyne-Stokes breathing in the adult, it is unlikely that these factors can furnish a complete explanation of the periodicity in the breathing of the newborn infant. This periodicity is only one phase of the great amount of irregularity found in infant breathing in all stages except A_{1_a}. It may be that the function of the respiratory centers is not so perfect at birth as we generally assume, and thus the Cheyne-Stokes breathing is only one indication of this imperfect respiratory control.

Occasionally we find an infant whose breathing is periodic throughout the period of experimentation, but this occurs very infrequently. Usually the periodicity occurs when the infant is fairly quiet, either when sinking into or coming out of a period of "deeper sleep" as defined in this study, just as Czerny (4) found that "breathing pauses" marked the boundary of deep sleep. Often an infant in condition A_{1_a} will show one or two such breathing groups immediately following the presentation of a stimulus, the breathing gradually resuming its former regularity. Such brief intervals of periodicity occur more frequently than longer intervals of periodic breathing.

Canestrini (2) found no Cheyne-Stokes breathing in his infants, but it is possible that he either observed too few cases or did not happen to secure conditions of deeper sleep in a sufficient number of cases. Peiper (17) reported an occasional prolonged pause in the breathing during sleep of two children 1½ and 7 years old respectively. Czerny (4) found no Cheyne-Stokes breathing in his subjects 23 days to 6 years of age, but did find frequent breathing pauses which he claimed were more frequent the younger the child; his diagram of these "breathing pauses" looks much like the less regular forms of Cheyne-Stokes breathing described by Wright. Probably he was using Howell's more rhythmical type as a criterion. Nevertheless, we have found even quite rhythmical groupings among our data.

The general question of typical sleep respiration may next be considered. Czerny's findings indicated the following changes: (*a*) going to sleep: fast breathing of average amplitude; (*b*) deepest sleep: slower breathing of least amplitude; (*c*) waking up: faster breathing as in (*a*), with the greatest amplitude of all. Now while we can pick out instances where this order is followed, it is difficult in many cases to compare rate and amplitude of any other stage with those in A_{1_a} because of the great irregularity of the breathing in all other conditions. Also, while it is true that in our own subjects the respiratory undulations are usually smoothly rounded as in Czerny's illustrations, there are also cases, some more extreme than

Figure 1, where there are sharp angles instead of smooth semicircles and where the amplitude can by no means be called "least" Czerny also found the expiration longer in the process of going to sleep Here again we can find occasional cases indicating such a tendency, but the cases are too few to be considered representative of the entire group

The regular breathing curves which Cramaussel found only in older children can be duplicated in our records secured from newborn subjects. As suggested before, Cramaussel studied too few subjects, and probably did not study his few subjects continuously enough to discover breathing typical of deep sleep.

Canestrini's (2) study of newborn infants revealed, like that of Czerny, that breathing becomes slower and weaker in sleep Often he noted disturbed respiration in the infant's sleep with no apparent external cause, this would correspond to our observations of irregularity in every condition except A_{1_a}.

In general, our study points to the vast amount of irregularity in the respiration of newborn infants rather than to definite, clear-cut generalizations such as those cited. We could select cases to fit every generalization made previously, but by so doing we would be neglecting the important fact of dominant irregularity which only an investigation involving a large number of cases with continuous records, like the present study, can reveal

The fact that an auditory stimulus may produce only a respiratory change in a sleeping infant has been pointed out by various investigators Czerny in 1892 claimed that the newborn infant is deaf, but a respiratory response alone to an auditory stimulus can be secured with an older child. Caramaussel in 1911 found that auditory stimuli do not affect the breathing curve of the newborn or very young infant, but in an infant 1½ months old the sound of the flute and other music will affect the breathing curve, the effect depending upon whether the observation is made at the beginning or at the end of sleep, and whether the sleep is more or less quiet or profound. Effects increase as the breathing becomes more irregular Here we have a hint of differential responses in terms of the depth of sleep. Canestrini in 1913 found that external stimuli, especially auditory, not strong enough to awaken the infant may yet modify the breathing curve Stern in 1924 did not specify breathing effects, but claimed that "sometimes noises will even cause twitching in sleep without waking the child" (p. 74), and that hearing in the infant produces invariable shock reactions. The first statement of his is true, according to our data, but the second is false, for otherwise we would have had about 100 per cent body-jerk responses to auditory stimuli. Statements attributing deafness to the newborn have long been discarded.

Recently Stubbs (22) made a study of sound effects on respiration, in the newborn infant, giving specifically the effects of duration, intensity, and pitch upon breathing. These changes were classed as slower or faster, deeper or shallower, more regular or less regular. We are dubious about the possibility of making arbitrary judgments of this sort except in condition A_{1_a}, where the breathing is quite regular. In any other condition it is usually hard to decide whether a given irregularity is the result of a stimulus or merely an accidental irregular form in an already irregular curve. Since in the present study the duration, intensity, and pitch were constant throughout the presentations, we can only compare our data where these factors have equivalent values in the other study.

With a five-second duration, Stubbs found 16.5 per cent of the stimulus presentations resulted in less regular breathing, and 29.1 per cent resulted in no response at all when the infant was "asleep", apparently this means "eyes closed and quiet" here. In our own data, a breathing-change-only, which roughly corresponds to the "less regular" breathing above, is found in 16.4 per cent of the cases in A_{1_a}, 18.0 in A_{1_b}, 13.0 in B_1, 12.9 in A_2, and 16.0 in A_3. Any one of these stages might have been included in the above category of "asleep," both because of its definition and because of the fact that the condition was an instantaneous judgment made every half minute. It is thus conceivable that B_2 and B_3 conditions could have slipped into the "asleep" category; our results for these in terms of breathing changes only are 6.6 per cent and 3.9 per cent. Outside of these two stages, our results agree fairly well with those of Stubbs if we may assume the identity of "breathing change only" and "less regular breathing."

The need for defining the "asleep" condition is more apparent in the discrepancy of Stubbs' no-response estimate of 29.1 per cent as compared with ours: 71.8 per cent in A_{1_a}, 56.2 per cent in A_{1_b}, 39.1 per cent in B_1, 27.6 per cent in A_2, 16.8 per cent in B_2, 14.0 per cent in A_3, and 5.0 per cent in B_3.

Since it is difficult to compare her sensation units of intensity with our own fixed intensity levels, we shall pass on to her data on pitch differences. Although she has no 2048 frequency, she did use 256. For this frequency there is less regular breathing in 4.3 per cent of the cases and 25.0 per cent no-response. Here again the need for more accurate specification of the "asleep" condition is indicated. In our own results the breathing-change-only occurs in 15.9 per cent of the cases in A_{1_a}, 18.5 in A_{1_b}, 14.3 per cent in A_2, 22.2 per cent in A_3, 8.7 per cent in B_1, 5.8 per cent in B_2, and 4.3 in B_3, the last being the only estimate agreeing with Stubbs'. The no-response results are 6.9 per cent for A_{1_a}, 52.3 per cent for A_{1_b} 29.8 per cent for A_2, 14.8 per cent for A_3, 17.4 per cent for B_1, 12.4 per cent for B_2, and 2.8 per cent for B_3.

Since the olfactory stimuli are identical to those employed by Disher (8), some comparison can be made between her results and our own. Although we have too few stimulus presentations to compare results for each odor separately, we can at least compare the totals. Disher found that with a 20-cc "stimulus value," 69 per cent of the infants as a whole made a response. Her sleep criterion includes at least our A_{1_a} and A_{1_b} stages, but for these conditions the per cent of the total stimulus presentation producing no response is 64.4 per cent and 49.1 per cent respectively, far beyond the estimate given by Disher. The other stages give per cents of no-response as follows. B_1—46.9; A_3—23.1, A_2—7.5, B_2—16.8, B_3—17.6; C_2—5.3, C_3—7.7; C_5—0. It may be that her sleep criterion allowed so many instances of other conditions besides A_{1_a} and A_{1_b} to be included, that the per cent of no-response was markedly decreased. On the other hand, the omission of two odors, asafoetida and citronella, which produced a high percentage of response in Disher's results, may have increased our own percentage of no responses. However, we also omitted pure air, which had the lowest percentage of responses in the other study. Therefore the latter explanation for the discrepancy of results seems less reasonable than the first one given above.

Still another study may be commented upon here—that of Irwin (13) on the distribution of the amount of activity in young infants between two nursing periods. He pointed out that while motility, as recorded by the stabilimeter, is least after feeding and increases steadily throughout the interval before the next nursing, the per cent of infants asleep is greatest about the middle of the interval and least at the beginning. He concluded that if overt inactivity is desired, the best time to experiment is right after feeding, but if sleep is desired, one should choose the middle of the period.

According to this, motility and depth of sleep are not parallel But this refers to gross motility sufficient to make a stabilimeter record There may be frequent slight stirs of body members at first, which are too slow or too slight to make a stabilimeter record, and hence a period of quiet would be recorded. During the middle of the period, when more sleep is reported, there may be enough body jerks or deep inspirations in the going-to-sleep process to give a record of activity greater than that obtained for the early part of the period Therefore, if inactivity in the infant, in an absolute sense, is desired, the first part of the period might still be less desirable than the middle part, with its relatively greater inactivity between the startles or body jerks. Here we assume, of course, that Irwin's sleep criterion—"eyes closed, body quiet"—probably includes more A_{1_a} and A_{1_b} conditions than any of the others we have listed. We also assume that his report concerning the relative distribution of the amount of sleep throughout the period is correct.

Gilmer (9) reported that she found no "chewing" movements in sleeping infants, though she gave no definition of sleep In the present study, however, "chewing," as a series of slight movements of the lower lip or jaw alone, did occur occasionally The mouth movement in the exceptional 45 cases where no eyelid movement accompanied it, was nearly always of this type. These instances occurred in conditions which would otherwise have been known as A_{1_a}, A_{1_b}, or B_1—conditions of relatively deep sleep, according to our criterion "Chewing" was also part of the mouth movements recorded for other conditions of lighter sleep, such as A_3 and B_3, which might also have been included occasionally in Gilmer's category of sleep

SUMMARY

A total of 197 newborn infants in various conditions of motility were given 5342 presentations of pain, tactual, olfactory, and auditory stimuli These conditions of motility were ranked as stages of depth of sleep in terms of the duration and extent of the responses made in each condition The stages in sleep depth thus determined, ranging from deepest to lightest sleep, are as follows·

1 A_{1_a}: Infant generally quiet; no eyelid or mouth movement, regular breathing.

2. A_{1_b}: Infant generally quiet; no eyelid or mouth movement, irregular breathing

3. B_1· Occasional stirs of body members, no eyelid or mouth movement

4 A_2, A_3, B_2 Infant generally quiet with eyelid movement, infant generally quiet with eyelid and mouth movement, occasional stirs of body members with eyelid movement.

5. B_3. Occasional stirs of body members, eyelid and mouth movement

6 C_2, C_4 *Infant generally active with eyelid movement, infant generally active with eyelid and mouth movement*

7 C_5, B_4, B_5: *Infant generally active, with eyes open and mouth movement;* occasional stirs of body members and eyes open, with *or without mouth movement.*

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ORDINAL POSITION AND THE BEHAVIOR DISORDERS OF YOUNG CHILDREN*

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The present study was undertaken in an effort to discover whether or not there is any positive and significant correlation between the order of birth of children and their "problems" or behavior disorders. Alfred Adler in *Problems of Neurosis* (2), claims that the *family constellation has its effects upon each member in an individual* and specific way. One of us [Wile (22)], has written that Adler's theory "practically creates a determinism of the characteristics based upon the order of birth." With this in mind, we have sought to determine the predominant characteristics of children in each of five positions in the family group, in order to ascertain if any trait is peculiar to a child in a specific ordinal position. We have correlated specific behaviors with such factors as sex, intelligence and age.

One hundred and twenty-five histories of children under eight years old were selected from the records of the Children's Health Class of Mt. Sinai Hospital. Twenty-five were selected to form each group of the following five groups: (*a*) *only* children, (*b*) *older* children from two-child families, (*c*) *middle* children from families of three or more children, (*d*) *younger* children from two-child families and (*e*) *youngest* children from families of three or more children. The histories were taken consecutively until the quota for each group was filled. In our discussion, therefore, we consider the groups as units and without reference to the percentage any single group forms of the total clinic population.

The ages of the children range from two years to eight years, the median chronological age for the entire group of 125 children being six years, three months. The IQ ranges from 38 to 131, with the median 105, indicating that the children were in the normal category with a distribution of IQ not very dissimilar to that of the general population. The Stanford Binet test, as administered and recorded by Miss Rose Davis, supplied our psychological data.

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The cultural and racial background of the children varied slightly, although the majority of them are of Russian Jewish descent and in the low middle economic class. Most of the parents are English speaking and the children attend the public schools in or near New York.

The information concerning behavior relates to the facts stated or elicited at the time of admission to the Children's Health Class. Almost all the histories were taken and written up by the same person, wherefore we believe that the descriptive terms employed to denote behavior reactions are reasonably consistent and reliable. Restlessness, for example, signifies any kind of hyperactivity noted and described by the mother or the teacher who referred the child to the clinic. Food fads represents any feeding problem which involves a refusal to eat. Unmanageable indicates that a child is very stubborn, objects to direction, or refuses to comply with reasonable *instructions. All other descriptive terms have their generally* accepted meanings.

Inasmuch as our problem centered upon the possible relation of the overt behaviors to order of birth, we shall omit unnecessary details concerning physical status. The physical factors may be disregarded, save to state that every child received a physical examination upon admission and all were found free from any significant or serious organic defect. If the weight of each child may be regarded as a loose index of his general health, it is worth noting that of the 125 children, 37 or about 28 per cent were within one pound of the average weight for their age and height. Of those more than one pound underweight, the median was three pounds underweight and of those more than one pound underweight, the median was four and one-half pounds overweight. Both of the deviations are insignificant because they are wholly within normal limits according to accepted standards.

We first studied the five groups of 25, based upon birth order, in a search for any outstanding traits of behavior characterizing any particular group. Our tabulation of the behaviors giving rise to complaints constitutes Table 1. We have arranged the items in diminishing order of frequency, employing as descriptive terms the symptoms in the reported disorder responsible for the child's presence at the clinic.

TABLE 1

BEHAVIOR DISORDERS IN ORDINAL POSITION GROUPS

Symptom	25 Only	Symptom	25 Older	Symptom	25 Middle
Restlessness	12	Restlessness	9	Temper tantra	9
Food fads	10	Quarrels with sibling	9	Intell retardation	9
Vomiting	9	Temper tantra	8	Enuresis	7
Temper tantra	7	Quarrels with others	8	Speech defect	6
Enuresis	6	Food fads	6	Unmanageable	6
Fears	6	Cries easily	5	Quarrels with sibling	6
Quarrels with others	6	*Nail biter*	5	Disobedient	6
M over protection	6	Enuresis	5	Quarrels with others	5
Destructive	5	Night terrors	5	Restlessness	5
Speech defect	4	M dresses and feeds	5	Swears	5
Converted sinistral	4	Vomiting	4	M feeds and dresses	4
M dresses and feeds	4	Fears	4	Tic	3
Intell retardation	3	Disobedient	4	Cries easily	3
Cries easily	2	School problem	4	Nail biter	3
Nail biter	2	Destructive	4	Stealing	3
Constipation	2	Unmanageable	3	Fears	3
Sucks thumb	2	Tic	3	Converted sinistral	2
Unmanageable	1	Masturbation	3	Shy	2
Tic	1	Converted sinistral	3	Infantile	1
Masturbation	1	*Speech defect*	2	*Truancy*	1
		Pains	2	Asthma attacks	1
		Shy	1	Masturbation	1
		M over protection	1	M over protection	1
		Retardation	1	Irritable	1
		Stealing	1	Sucks thumb	1
		Irritable	1	Vomiting	1
				Pains	1

Symptom	25 Younger	Symptom	25 Youngest
Temper tantra	10	Restlessness	10
Quarrels with sibling	9	Food fads	9
Fears	8	Temper tantra	8
Restlessness	6	Disobedience	8
Enuresis	4	Converted sinistral	7
Vomiting	4	Vomiting	7
Converted sinistral	5	M dresses and feeds	6
Food fads	4	*Quarrels with others*	6
Quarrels with others	4	Enuresis	5
Unmanageable	4	School problem	5
Swearing	3	Nail biter	5
Sleeps badly	3	Unmanageable	4
Destructive	3	Speech defect	4
Irritable	3	Tic	3
Pains	2	Masturbation	3
Nail biter	2	Pains	3
Dislikes school	2	*Cries easily*	3
Cries easily	2	Fears	3
Shy	2	Quarrels with sibling	2
Speech defect	2	Irritable	2
Masturbation	2	Destructive	2
Fights	2	Swears	2
Tic	1	M over protection	2
Delinquency	1	Constipation	1
Asthma attacks	1	Shy	1
Truancy	1		

Table 1 shows that in no group do more than 48 per cent of the children show the same trait Variation of behavior is as marked within each group, as it is between the groups This immediately suggests that the order of birth is not a deterministic factor Position in the family constellation does not manifest itself, as, or in, any particular trait in a majority of the cases of any group, which should be the fact, if the ordinal position was responsible for, or even was consistently accompanied by, definite behavior trends or patterns.

Our next problem was to ascertain whether or not the presence of one specific behavior was consistently accompanied by any related manifestation of dysharmony. If a child consistently refused food, would he also vomit when the food was forced? To solve this we listed the four traits of most frequent occurrences in each group along with the other symptomatic behaviors which accompanied them This is compiled as Table 2.

Table 2 clearly demonstrates that none of the enumerated behaviors is accompanied consistently by another behavior disorder In a few instances one symptom may be associated to the extent of 50 per cent with another specific behavior, but this is contrary to the general findings. Among the 25 *only* children, restlessness occurred 12 times and in only half of the occasions was it accompanied by food fads. Food fads of 10 children were accompanied by restlessness in six cases. On the other hand, restlessness was not associated with any other symptom to the extent of 50 per cent, while 50 per cent of food fads were accompanied by vomiting, and vomiting was accompanied by almost 60 per cent of food fads. Temper tantra were associated with restlessness and quarreling with others to the extent of 50 per cent. Hence specific symptom association does not exist within this group The identical fact is obvious from a glance at the data of Table 2 that applies to the *older,* the *younger,* the *middle* and the *youngest* child. As is patent from Table 2, and we are aware that the numbers are few (25 in each group), there is no evidence of a basic concomitance between coexistent symptoms as they appear in any one of the five categories (all below 50 per cent), which would be necessary, if the behaviors were determined by the ordinal position, as urged by Adler

The four most frequent traits for each group were retabulated, in terms of their approximate percentage of occurrence in each group, in order to compare these types of behavior in terms of their relative

TABLE 2

THE FOUR MOST COMMON SYMPTOMS FOR EACH GROUP AND THEIR ACCOMPANYING SYMPTOMS IN ORDER OF FREQUENCY

	For the only child 25		
Symptom			
Restlessness	12 accompanied by	*Food fads*	10 accompanied by
Food fads	6	Restlessness	6
Temper *tantra*	5	Vomiting	5
Quarrels with others	5	Quarrels with *others*	4
M over protection	4	M over protection	3
Vomiting	3	Enuresis	2
Destructive	3	Speech defect	2
Converted sinistral	3	Fears	2
Speech defect	2	Temper tantra	2
Enuresis	2		
Fears	2	*Vomiting*	9 accompanied by
Constipation	2	Food fads	5
M dresses	2	Restlessness	4
Nail biter	2	Sucks thumb	3
		Fears	2
Temper tantra	7 accompanied by	Speech defect	2
Restlessness	5	Nail biter	2
Quarrels with others	4	M over protection	2
Destructive	3	Enuresis	2
Food fads	2		

TABLE 2 (*continued*)

Symptom	For the older of two 25		
Restlessness	9 accompanied by	*Quarrels with sibling*	9 accompanied by
Temper tantra	4	Food fads	4
Quarrels with others	4	Temper tantra	3
Food fads	3	Unmanageable	2
Nail biter	3	Quarrels with others	2
Cries easily	2	M over protection	2
Enuresis	2	Vomiting	2
Vomiting	2	Disobedient	2
M feeds and dresses	2	M feeds and dresses	2
Converted sinistral	2	School problem	2
School problem	2		
Temper tantra	8 accompanied by	*Quarrels with others*	8 accompanied by
Restlessness	4	Restlessness	4
Food fads	4	Temper tantra	3
M. feeds and dresses	4	Nail biter	3
Cries easily	3	Disobedient	3
Quarrels with others	3	Cries easily	2
Unmanageable	2	Quarrels with sibling	2
Quarrels with sibling	2	Enuresis	2
Masturbation	2	Vomiting	2
Converted sinistral	2		

TABLE 2 (*continued*)

Symptom	For the middle child 25		
Temper tantra	9 accompanied by	*Intellectual retardation*	8 accompanied by
Quarrels with others	4	Quarrels with others	3
Unmanageable	3	Unmanageable	3
Enuresis	3	Stealing	2
Stealing	2	Swearing	2
Swearing	2	Restlessness	2
Speech defect	2	Temper tantra	2
Fears	2	Shy	2
Quarrels with sibling	2		
Cries easily	2	*Enuresis*	7 accompanied by
Restlessness	2	Temper tantra	3
Retardation	2	Cries easily	3
		Nail biter	2
		Speech defect	2
		Quarrels with others	2
		Swears	2
		Unmanageable	2

TABLE 2 (*continued*)

	For the younger of two 25		
Symptom			
Temper tantra	10 accompanied by	*Quarrels with sibling*	9 accompanied by
Vomiting	3	Fears	4
Destructive	3	Restlessness	4
Quarrels with others	2	Temper tantra	3
Swearing	2	Enuresis	2
Unmanageable	2	Unmanageable	2
Enuresis	2	Food fads	2
Fears	2	*Fears*	8 accompanied by
Restlessness	2	Quarrels with sibling	4
Quarrels with sibling	2	Temper tantra	3
Pains	2	Restlessness	2
Food fads	2	Converted sinistral	2
Restlessness	6 accompanied by	Vomiting	2
Quarrels with sibling	4		
Temper tantra	2		
Fears	2		
Sleeps poorly	2		

TABLE 2 (*continued*)

Symptom	For the youngest child 25		
Restlessness	10 accompanied by	Food fads	9 accompanied by
Food fads	4	Restlessness	4
Disobedience	3	Temper tantra	4
Converted sinistral	3	Vomiting	3
School problem	2	Disobedience	3
Nail biter	2	Tic	2
Masturbation	2	School problem	2
Vomiting	2	M feeds and dresses	2
Unmanageable	2	Quarrels with others	2
M. dresses and feeds	2		
Temper tantra	2	*Temper tantra*	8 accompanied by
		Quarrels with others	5
Disobedience	8 accompanied by	Food fads	4
Restlessness	5	Disobedience	3
Nail biter	4	Enuresis	2
Quarrels with others	3	Converted sinistral	2
Temper tantra	3	Restlessness	2
Food fads	3	Unmanageable	2
Masturbation	2	Quarrels with sibling	2
M feeds and dresses	2		

intergroup frequency Three traits were common to two groups so that the list of behaviors total seventeen instead of twenty.

The probable significance of the percental differences of specific behaviors in the several groups varied considerably, hence the statistical meaning requires study at this time, especially in the light of the small numbers involved

Example 1. Restlessness was found in 48 per cent of the cases of *only* children, and in 40 per cent of *youngest* children—a difference of 8 per cent. Is this difference statistically significant, when based, in each case, on only 25 cases? Or, what is the PE of this difference? (PE = a measure on each side of the mean within which one-half the cases would fall Or, what are the chances that a similar difference (i e, a difference greater than zero in the same direction) would be found in other and larger samples?

Let p = Standard Deviation of a proportion or percentage

$$p = \frac{pq}{n} \qquad (1)$$

$$\mathrm{PE} = .6745 \frac{pq}{n} \qquad (2)$$

$$\mathrm{PE}_{diff} = \sqrt{\mathrm{PE}_1^2 + \mathrm{PE}_2^2} \qquad (3)$$

Where p = per cent or proportion; q = difference between p and 1 00; n = number of cases, p and q vary between 0 0 and 1 00. By formula (2), PE of 48 per cent = .067 and PE of 40 per cent = .066[1] By formula (3), $067^2 = .004543$, $066^2 = .004369$ $\sqrt{004543 + 004369} = \sqrt{.008912}$. PE = 094. The PE of this difference of 8 per cent based on 25 cases equalled 094, while the observed difference was only .08; · since the PE is larger than the observed difference of 8 per cent it may be due to pure chance If the observed difference is twice as great as the PE, the chance that it is not due to pure chance is 4½ to 1,

Observed difference equal to PE	Chance of occurrence
1 PE	1 to 1
2 PE	4½ to 1
3 PE	22 to 1
4 PE	142 to 1

In the present study most of the differences of less than 15 per cent are of doubtful significance (PE's tend to fluctuate between 05 and 09 The exact significance would, of course, have to be computed in each case)

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[1] Table of standard errors and probable errors of percentages for varying numbers of cases, by H A Edgerton and D G Paterson, *J Appl Psychol*, 1926, 10, 378-391

Example 2

M over-protection, *Only*, 24 per cent, *Youngest*, 8 per cent, diff, 16 per cent

$$\begin{aligned} \text{PE } p &= 057^2 = 003282 \ (24\%) \\ \text{PE } p &= 036^2 = 001325 \ (\ 8\%) \\ &\quad \sqrt{004608} \\ &= 0678 \\ &= 07 \end{aligned}$$

The chances are more than 4½ to 1 that difference is not due to mere chance

Obviously the status of being an *only* child or the *youngest* child of a family is pure chance If, therefore, maternal over-protection, as a complaint, is not due to pure chance, the determining factor may be in the mother, rather than the ordinal position or in some function of the total family-mother-child situation The truth of this appears in such differences as involve a zero percentage in one or more of the groups, as

Food fads	*middle* 0%
Maternal over protection	*younger* 0%
Mother feeds and dresses	*younger* 0%
Disobedient (only 0%)	*younger* 0%
School problem (only 0%)	*middle* 0%
Intellectual retardation	*younger* 0%, *youngest* 0%

A lack of ability to quarrel with siblings, however, is definitely due to ordinal position, which becomes apparent, upon noting that the *only* child group quarrels with others, as frequently as the *youngest* group, and hence possesses the ability to quarrel Converted sinistral, however, is not a condition due to ordinal position, as dominant handedness is not affected by birth order, although the rise in the complaint from *only*, to *older*, to *younger*, to *youngest*, suggests that increasing experience and pattern might be operative Patently the *middle* groups would be low, if conversion were practiced on *only*, *older* and *younger* children

That disobedience was not a complaint for *only* and *younger* children and rises from *older*, to *middle*, to *youngest* children, again suggests that the complaint is a function of a total situation, and not a primary element of the ordinal position—obviously *only* and *younger* children disobey, though they were not among this group of children referred to the clinic This applies to maternal over-protection and mother feeds and dresses, which were not complaints in the group of *younger* children

Reference to the frequency percentages in Table 3 demonstrates

TABLE 3
PERCENTAL DISTRIBUTION OF SPECIFIC DISORDERS AND THEIR COMPARATIVE AND INTERGROUP RELATIONS

In ( ) will be found the relative frequency of the symptoms in the five groups, 5 being the highest frequency and 1 being the lowest.

Symptom		Only	Older	Middle	Younger	Youngest
Restlessness		48(5)	36(3)	20(1)	24(2)	40(4)
Food fads		40(5)	24(3)	0(1)	16(2)	36(4)
Vomiting		36(4)	16(1)	44(5)	16(2)	28(3)
Temper tantra		28(1)	32(3)	36(4)	40(5)	32(2)
Enuresis		24(4)	20(3)	28(5)	16(1)	20(2)
Fears		24(4)	16(3)	12(1)	35(5)	12(2)
Quarrels with others		24(3)	32(5)	20(2)	16(1)	24(4)
M over-protection		24(5)	4(3)	4(2)	0(1)	8(4)
Quarrels with sibling		0(1)	36(4)	24(3)	36(5)	8(2)
Intelligence retardation		12(4)	4(3)	32(5)	0(1)	0(2)
Speech defect		16(2)	8(1)	24(4)	44(5)	16(3)
Unmanageable		4(1)	12(2)	24(5)	16(3)	16(4)
Disobedient		0(1)	16(3)	24(4)	0(2)	32(5)
Converted sinistral		12(2)	16(3)	8(1)	20(4)	28(5)
M feeds and dresses		20(4)	16(3)	16(2)	0(1)	24(5)
School problem		16(4)	0(1)	0(2)	8(3)	20(5)
Nail biter		20(4)	8(1)	12(3)	8(2)	20(5)
Total frequency		54	46	50	46	60
	Weighting					
Total	(5)	3	1	4	4	5
	(4)	6	1	3	1	5
Rating positions						
	(3)	1	10	2	2	2
	(2)	3	1	4	5	0
	(1)	4	4	4	6	5

the percental distribution of each symptomatic behavior for each of the five groups. It appears that temper tantra occur most frequently among the *younger* and *middle* children, who have older siblings to annoy them and prevent them from attaining their wishes. Maternal over-protection is a more significant problem of the *only* children than of the other types. One notes that the mother tends to prolong the dressing and feeding of her youngest child, frequently her only child. Table 3 reveals many differences, some as marked as food fads, others as trifling as enuresis.

Ratings were made for the frequencies of a symptom in the group, five representing the highest and one the lowest frequency. These have been used as weightings, for purposes of rough comparison only, as all the assigned ratings are not wholly valid, as when the percentages are identical for two or more groups, one of them is rated as higher. Furthermore our groups are statistically too small to warrant complete dependence upon the percentage calculations Further it is proper to note here that the disorders complained of are mere tabulated symptoms, and do not represent single behaviors for which the children were referred to the clinic It is patent that the actual reasons for taking a child to a clinic must involve, not merely the family constellation, but also the nature of the problem, which includes the home situation, which we have ignored so as not to complicate our survey of the ordinal position as a dominant factor The frequency of rating positions indicates that of the groups the *youngest* child has 10 of [5] and [4], followed in order by *only* child with 9, *middle* child 7, *younger* child 5, and *older* child 2 The implication of this fact is not wholly warranted because of the diverse character of the behaviors rated—thus it is not logically or scientifically sound to compare the meaning or relative hazards of such undesirable factors as converted sinistral, nail biter, restlessness, enuresis and fears. Despite these admitted weaknesses, we believe our method is warranted for its suggestive data

The two groups having the highest weighting of frequency as computed for the groups were the *youngest of many* [60] and the *only* child [54] groups. The difference between the *youngest* child [60] and the *younger* child [46] groups, is 14 points This is significant and suggests that the *youngest* child has a familial position more similar to that of the *only* child than to that of the *younger* child in terms of frequency of undesirable reactions This is not in accord with Dr Adler's theory. The *only* child has the heaviest weighting in restlessness, food fads, and maternal over-protection, while the youngest child is second in these traits The *youngest* child has the heaviest weighting in nail biting, school problems, and mother dressing and feeding, in which traits the *only* child has a close second weighting

A comparison of the *older* and *younger* groups indicates an identical weighting for the *older* [46] and for the *younger* [46] child It is noteworthy that quarrels with others is more common among the *older* than the *younger* group The *older* group holds the median position for 10 of the 17 symptoms, with the highest rating for quarreling and lowest rating for vomiting, speech defects, school problems and nail biting. It appears that the *older* child is a very

TABLE 4

DIFFERENCES OF MORE THAN 15 PER CENT (THE FIRST NAMED HAVING THE HIGHER PERCENTAGE)

Restlessness	Only > middle younger	Older > middle	youngest > middle
Food fads	Only > older middle younger	Older > middle	youngest > middle younger
Vomiting	Only > older younger	Middle > older younger youngest	youngest > younger
Temper 0			
Enuresis 0			
Fears	Younger > older middle youngest		
Quarrels with others	Older > younger		
M over-protection	Only > older middle younger youngest		
Quarrels with sibling	older > youngest	Middle > youngest	younger > youngest
Intelligence retardation	Middle > only older younger youngest		

TABLE 4 (*continued*)

Speech defect	middle > older	younger > only older middle youngest		
Unmanageable	middle > only			
Disobedient	older > only younger	middle > only younger	youngest > only older middle younger	
Converted sinistral	youngest > only middle			
M feeds and dresses	Only > younger	older > younger	middle > younger	youngest > younger
School problem	Only > older middle	youngest > older middle		
Nail biter 0				

ordinary person and presents fewer outstanding disorders than the other groups of children

The *middle* group and the *younger* child afford some striking contrasts, as in food fads, intellectual retardation and disobedience. The *middle* group presents the most frequent occurrence of vomiting enuresis, retardation, and unmanageability The *younger* child group exhibits temper tantra, fears and quarrels with sibling and speech defects most frequently of all the groups.

Table 4 lists the observed differences of more than 15 per cent, in which the likelihood that the difference is due to more than pure chance is at least 4½ to 1 It is noticeable that temper tantra, enuresis and nail biting are not within the category of chance One now notes the following interesting facts

Restlessness is least frequent among the middle group
Food fads are least frequent among the middle group
Vomiting is least frequent among the younger group
Fears are least frequent among the middle and youngest groups
Quarrels with others are least frequent among the younger group
Quarrels with siblings are least frequent among the youngest group.
Speech defect is least frequent among the older group
Unmanageable is least frequent among the only group
Disobedience is least frequent among the only group
M. feeds and dresses is least frequent among the younger group
School problems are least frequent among the older and middle group
Restlessness and food fads are most frequent in *only* groups
Vomiting is most frequent in *middle* group.
M over-protection is almost limited to *only* group
Intellectual retardation is almost limited to *middle* group
Speech defect is almost limited to *younger* group
Fears are most frequent in *younger* group.
Disobedience is most frequent in *youngest* group.
Converted sinistrals are most frequent in *youngest* group
School problem is most frequent in youngest group
Quarrels with others is most frequent in older group
Mother feeds and dresses is most frequent in *youngest* group.

Rearranging these data, where a difference of more than 15 per cent occurs, one finds the following peculiar grouping of behaviors, reflecting mixtures of personality traits and specific behaviors

Only child	Least frequent	unmanageable, disobedient
	Most frequent	restlessness, food fads, vomiting, maternal over-protection
Older child	Least frequent	speech defects, school, problem
	Most frequent	quarrels with others.

Middle child	Least frequent	food fads, fears, school problems, vomiting.
	Most frequent	intellectual retardation, quarrels with others.
Younger child	Least frequent	vomiting, quarrels with others, mother feeds and dresses.
	Most frequent	speech defects, fears.
Youngest child	Least frequent	fears, quarrels with siblings.
	Most frequent	disobedient, converted sinistral, school problem, mother feeds and dresses.

Various inconsistencies appear which cast further doubt upon the influence of ordinal position Thus to find intellectual retardation most frequent and school problem less frequent in the *middle* group raises a question of the influence of birth order This holds true for the *youngest,* with quarrels with siblings least frequent, and disobedience most frequent, and even more so for maternal over-protection most frequent among the *only,* with the mother feeds and dresses most frequent among the *youngest* child group.

The numerical range of symptoms presented by each child was found to be from 1 to 8, with a median of 4 for each group The specific symptoms, however, varied in the groups as is manifest in Table 5, which lists the four most frequent behaviors characterizing each group

TABLE 5

THE FOUR SYMPTOMS MOST FREQUENT IN COMPLAINTS

Only child	Older of two	Middle child	Younger of two	Youngest child
Temper tantra	Temper tantra	Temper tantra	Temper tantra	Temper tantra
Restlessness	Restlessness	*Retardation*	Restlessness	Restlessness
Food fads	Quarrels with sibling	*Enuresis*	Quarrels with sibling	Food fads
Vomiting	*Quarrels with others*	*Speech defect*	*Fears*	*Disobedience*

Each group manifests at least one behavior, italicized, which does not appear in the other groups while the *middle* child group has three peculiar to itself Otherwise there is a good deal of similarity. Temper tantra is common to all the groups, indicating that its occurrence is not due to ordinal position Restlessness occurs in all groups except *middle* child, while food fads, quarrels with sibling appear in the *only* child and *youngest* child groups, which have three of the four behaviors in common. The most individualized group is the *middle* child, which presents three behavior disorders which do not appear in any other group.

The nature of retardation and speech defect suggests that they are not based upon ordinal position. What was the effect of intelligence level upon the various behavior disorders? To answer this we selected the 25 children having the lowest IQ's from the 125 histories. They ranged from IQ 38 to 92, with the majority between 70 and 90, and the median at 81. Another group of 25 was selected with IQ's ranging from 119 to 131, the majority between 112 and 128, with the median at 123. The distribution of these children in the family constellation appears in Table 6.

TABLE 6
DISTRIBUTION IN THE FAMILY CONSTELLATION

	Low IQ's 38-92	High IQ's 119-131
Only	4	7
Older	4	6
Middle	10	3
Younger	2	6
Youngest	5	3

The outstanding group in the low IQ is the *middle* child. Ten of the 25 children with the lowest IQ of the entire group are *middle* children. This leads us to inquire whether the behavior disorders presented for the *middle* child in Table 5 were more definitely related to the low IQ rather than to the ordinal position. A partial answer is found in Table 7.

TABLE 7
THE AGES AND INTELLIGENCE QUOTIENTS OF 125 CHILDREN

Median	Only	Older	Middle	Younger	Youngest	Total group
CA	5-1	6-9	7-3	6-4	6-3	6-3
MA	5-6	7-0	6-4	6-9	6-10	6-6
IQ	*105*	*107*	*97*	*108*	*103*	*105*
Range	69-131	87-131	38-125	79-128	78-126	38-131

Table 7 shows that the *middle* child group has a median IQ six points below that of the next higher group (*youngest*) and eleven points lower than that of the highest group (*younger*). The critical ratio was found for this six points of difference between the *middle* group and the *youngest* group $\frac{D}{PE_{diff}} = .26$, which means that the chances are approximately 60 in 100 that the observed difference is not due merely to chance The difference of eleven points between the *middle* child group and the *younger* child group was studied by the same formula, $\frac{D}{PE_{diff}} = .79$, which implies that the chances are approximately 80 in 100 that this difference is not due merely to chance

The difference of the medians of the four other groups do not suggest that the IQ was an influence in the formation of their dominant behavior patterns That the IQ was probably more significant than ordinal position for the *middle* child group is evident, in the relatively higher median CA that it presents, along with the relatively lowest median IQ

TABLE 8

THE EIGHT DOMINANT SYMPTOMATIC BEHAVIORS

Low IQ's 38-92 Symptom	No of cases	High IQ's 119-131 Symptom	No of cases
Temper tantra	9	Temper tantra	12
Quarrels with others	9	Quarrels with others	11
Restlessness	7	Restlessness	10
Retardation	9	Food fads	9
Enuresis	7	Quarrels with sibling	8
Unmanageable	6	Destructive	7
M dresses and feeds	6	M. dresses and feeds	6
Speech defect	5	Nail biter	6

Table 8 lists the eight behaviors which occurred most frequently in the low IQ and the high IQ groups, shown in Table 6

According to Table 8 retardation, enuresis, unmanageability, and speech defect appear in the low group but not in the high group. This corroborates our suspicion concerning the part that the IQ plays in causing the problems of the *middle* group, as these are the very symptoms found excessively in that group Inasmuch as 40 per cent of our *middle* child group have IQ's below 92, and approximately the same percentage of our low IQ group presents retardation, it is fairly safe to assume that this symptom of low intellectual powers is not due to position in the family (although, of course, these may not be exactly the same children) It would not be surprising if there were a relation between the low IQ and the enuresis, unmanageable, and speech defect. It is interesting to note that in both groups many children exhibit restlessness, temper tantra and quarreling, and the greater incidence in the high IQ group suggests *that the IQ is more important than* the ordinal status, because the high IQ's are very evenly distributed in the *only, older* and *younger* groups It is probable that mothers dress and feed their children if they are dull and need help or if they are bright enough to demand maternal assistance, as no marked quantitative difference in these traits appear in the two groups. The food fads, quarrels with sibling, destructiveness and nail biting of the high IQ group do not appear in the low IQ group. Aggressive traits have a higher frequency in the high IQ group, which also makes it reasonable to believe that certain behavior trends are more closely related to intellectual levels than to ordinal position

To determine if sex were a marked determiner, we noted the behaviors for girls and boys Perhaps the most significant finding in relation to sex is that approximately twice as many boys as girls had been selected in the random selection of our clinic histories—83 boys and 42 girls.

Table 9 clearly demonstrates that there are few marked differences of behavior patterns of this young group in terms of sex This is *what would be expected in terms of the undifferentiated sexual urges* of this latent period Patently the sex factor is not specifically related to level of intelligence or to ordinal position. The general similarity of the behavior symptoms and their percental occurrence is exhibited in Figure 1

In Figure 1 slight differences are evident in a few traits and none exceed 16 per cent The maximum percental difference occurred for retardation, and, therefore, we computed the medians for both sexes which were found to be as follows:

Median	CA	MA	BA	IQ
Girls	6-8	6-10	6	106
Boys	62	6-4	5	104

This indicates that the girls as a group were slightly higher than the boys in theoretical intellectual ability. The graph therefore shows that the complaining term "retardation," although it is applied more

TABLE 9

BEHAVIOR DISORDERS AND THEIR FREQUENCY OF OCCURRENCE ACCORDING TO SEX

Girls (42)			Boys (83)		
Symptom	No	%	Symptom	No	%
Temper tantra	13	30	Restlessness	31	37
Food fads	12	28	*Temper tantra*	30	36
Quarrels with others	11	26	Quarrels with others	22	27
Vomiting	10	23	Food fads	19	23
Restlessness	10	23	*Enuresis*	18	21
Fears	10	23	Quarrels with sibling	17	20
Unmanageable	10	23	Vomiting	16	19
Enuresis	9	21	*Unmanageable*	16	19
Converted sinistral	8	19	M. feeds and dresses	16	19
Quarrels with sibling	8	19	Destructive	16	19
Retardation	7	17	*Nail biter*	14	16
Nail biter	6	14	Converted sinistral	14	16
Shy	6	14	Speech defect	13	15
Tic	5	11	*Cries easily*	13	15
School problem	5	11	School problem	13	15
Destructive	4	9	Fears	10	12
M dresses and feeds	4	9	*Masturbation*	10	12
Irritable	3	7	M over-protection	9	10
Speech defect	3	7	Night terrors	9	10
Constipation	2	6	*Disobedient*	7	8
M over-protection	2	6	Swears	7	8
Cries easily	2	6	Tic	6	7
Swears	2	6	*Pains*	6	7
Pains	2	6	Stealing	4	4
Disobedient	2	6	Irritable	3	3
Stealing	1	2	Shy	3	3
Night terrors	1	2	Retardation	2	2
Asthma attacks	1	2	Asthma attacks	2	2
			Constipation	1	1
			Delinquency	1	1
			Truancy	1	1

frequently to girls than to boys, cannot refer specifically to intellectual level *This apparent disparity on the graph must picture* not an actual limitation of ability but rather judgments affecting *the mental achievement of the girls* and boys. Other differences which seem large are more readily explained, as for example, the presence of masturbation in 12 per cent of the boys and in none of the girls This is primarily due to the accessibility of the male genitalia and has no relation to the ordinal position, as is shown by its prevalence in all the groups (Table 1) The marked difference in restlessness, 23 per cent girls, 37 per cent boys, is referable to the hyperkinesis, which is normal in boys in all ordinal positions.

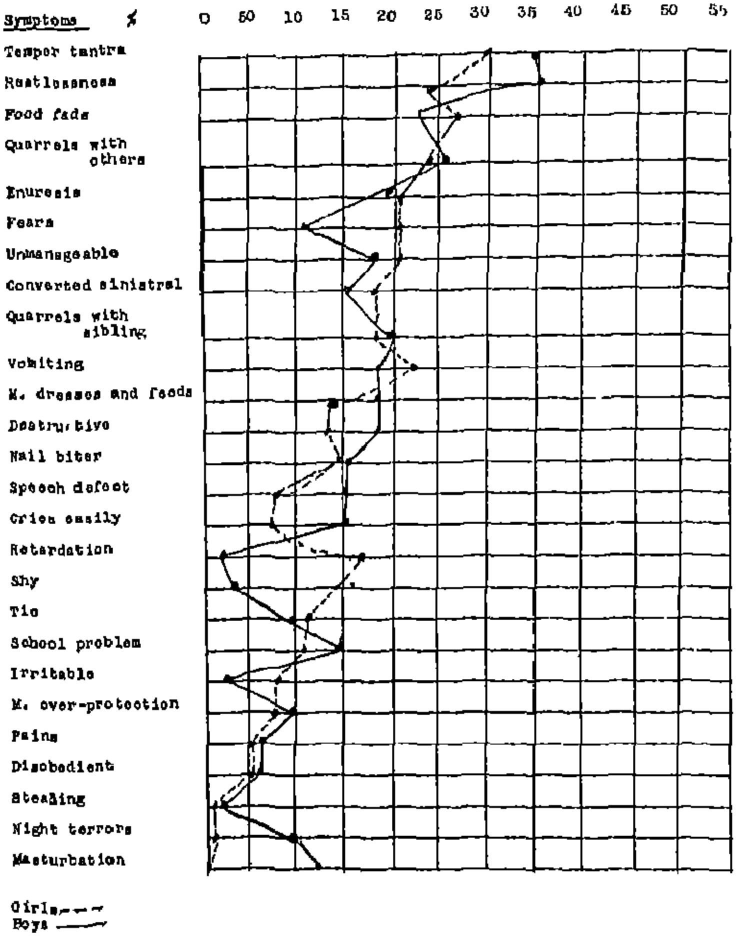

FIGURE 1
SHOWING DATA FROM TABLE 9

The similarity of the sexes in behavior becomes apparent in such traits as disobedience, maternal over-protection, nail biting, irritability, converted sinistrality, quarrels, tics, pains, stealing and enuresis The percentages probably are distorted because of the small number of the entire group and the inequality of the sexes The limited data warrant the conservative conclusion that sex was not an essential factor in the great majority of behavior problems characterizing our entire group

The children were grouped according to various ages in order to ascertain whether or not age was a marked determiner of undesirable behavior patterns

Tables 10 and 11 reveal the four most prominent symptoms, according to frequency, for each of these age groups.

TABLE 10

PERCENTAL OCCURRENCE OF DISORDERS AMONG CHILDREN OF SIMILAR AGES

Number	
24	CA between 5-6 years Restlessness (50%) temper tantra (42%), food fads (42%)
15	MA between 5-6 years Speech defect (33%), temper tantra (26%), restlessness (26%), unmanageable (26%)
27	BA of 5 years Restlessness (48%), temper tantra (37%), quarrels with others (37%), unmanageable (25%)
36	CA between 6-7 years. Restlessness (30%), quarrels with sibling (30%), quarrels with others (26%), unmanageable (26%)
35.	MA between 6-7 years Restlessness (43%), temper tantra (31%), food fads (25%), quarrels with others (23%)
34.	BA of 6 years. Restlessness (32%), temper tantra (29%), quarrels with others (29%), unmanageable (26%)
36	CA between 7-8 years Temper tantra (30%), restlessness (26%), quarrels with others (25%), unmanageable (25%).
30	MA between 7-8 years Quarrels with sibling (36%), restlessness (33%), temper tantra (33%), nail biter (27%)
20	BA of 7 years. Restlessness (35%), school problem (30%), quarrels with sibling (30%), fears (25%)

TABLE 11

Number	
24.	CA between 5-6 years Restlessness (50%), temper tantra (42%), food fads (42%), quarrels with others (33%)
36	CA between 6-7 years Restlessness (30%), quarrels with siblings (30%), unmanageable (26%), quarrels with others (26%)
36	CA between 7-8 years Restlessness (26%), temper tantra (30%), unmanageable (25%), quarrels with others (25%)
15	MA between 5-6 years. Speech defect (33%), temper tantra (25%), restlessness (26%), unmanageable (26%)
35	MA between 6-7 years Food fads (25%), temper tantra (31%), restlessness (43%), quarrels with others (23%)
30	MA between 7-8 years Nail biter (27%), temper tantra (33%), restlessness (33%), quarrels with siblings (35%)
27.	BA 5 years Restlessness (48%), temper tantra (37%), unmanageable (25%), quarrels with others (37%).
34	BA 6 years Restlessness (32%), temper tantra (29%), unmanageable (26%), quarrels with sibling (29%)
20	BA 7 years Restlessness (35%), school problem (30%), fears (25%), quarrels with sibling (30%).

Tables 10 and 11 show restlessness, temper tantra and quarrels with others at each of the age levels, with a tendency to decline with the rise of CA and BA rather than with MA Considering the group CA 5-6 years, one notes a slightly closer relationship between its behavior patterns and the group BA 5 years than with the group MA 5-6 years. Restlessness shows 50 per cent and 48 per cent and temper tantra shows percentages of 42 per cent and 37 per cent for CA 5-6 years and BA 5 years as contrasted with 26 per cent among those with MA 5-6 years. Children with a CA 5-6 or BA of 5 appear to quarrel with others, 33 per cent and 37 per cent, but this trait does not appear among the first four behaviors of the group MA 5-6 years

Omitting an analysis of other CA groups this discrepancy called for further study of the basal age. It is interesting to note the amount and frequency of deviation from the basal age as recorded in Table 12.

Inasmuch as Table 12 demonstrates a normal deviation of BA

TABLE 12

SHOWING DEVIATION FROM THE BASAL AGE

CA 2-4 yrs (14) Median BA 3 Deviation from			*CA 4-5 yrs. (16)* Median BA 4 Deviation from			*CA 5-6 yrs. (25)* Median BA 5 Deviation from		
CA		MA	CA		MA	CA		MA
	+2			+2			+2	
1	+1		3	+1		6	+1	
13	at	10	8	at	8	10	at	11
	—1	3	4	—1	7	3	—1	12
	—2	1	1	—2	1	6	—2	2
	—3			—3			—3	
At	Median	At	At	Median	At—1	At	Median	—1

CA 6-7 yrs (37 Median BA 6 Deviation from			Median BA 7 Deviation from		
CA		MA	CA		MA
	+2		1	+2	
4	+1		3	+1	
21	at	14	11	at	17
10	—1	19	9	—1	13
1	—2	3	4	—1	3
1	—2	1	3	—3	
			2	—4	
At	Median	—1	—1	Median	At

from CA and MA from all CA groups, it is suggestive that the behaviors showing a high correlation of percentages in the CA and BA groups of Tables 10 and 11 may be regarded as affected by the level of maturation. This is again only secondarily related to ordinal position.

A comparison of our findings with the data of other investigators adds various degrees of support to our conclusions. Grace Arthur (3) *points out that IQ's seem to be higher for the younger siblings* than for the first born. Studying Minnesota Kindergarten children, all of whom were tested at the end of the year by the Kuhlman Binet Scale, she found for 92 pairs of siblings that the median IQ of the older one was 93.05±11.29 and that of the younger was 99.14±10.42. She holds that the difference is significant, because there is less than one chance out of a hundred that the six points *of difference would change if another group were tested.* She then tested the siblings of 85 families, containing three children each, with the following results (with our figures in parenthesis for comparison)

Older	82.70	(107)
Middle	90.34	(97)
Youngest	95.34	(103)

As the children she tested were of foreign descent, and in some cases had a language difficulty, she reduced the group to include only those with American surnames, but found an insignificant difference of 1.0. The standard deviation was found to be greater for the older child and the difference seemed to increase with CA.

Thurstone and Jenkins (20) agree with her, although their studies embraced 1,430 children recorded at the Institute of Juvenile Research, who ranged from one to twenty-one years. They state. "The fact that 23 out of 28 comparisons favor the later-born sibling and the further fact that all of the comparisons involving large samples *consistently favor the last-born seem to justify* the conclusion that intelligence increases on the average with order of birth in the same family." In their conclusion, they remark concerning the only child, "Neuropathic tendencies are usually frequent among only children." Among the behaviors, they report incest, and a frequency of fear, disturbed sleep, constipation, and enuresis. A disproportionately large number of first borns were found among the problem children.

Harold Ellis Jones (9) points out the many handicaps of the first born, indicating that prenatal conditions are relatively unfavorable, *the percentage of premature births is higher; the duration of labor* is longer; and the first born child tends to be a lighter and smaller *child. Jones presents the following table* (Table 13). (Our own figures are in parenthesis for comparisons.)

TABLE 13

A COMPARISON OF IQ'S OF 1ST AND 2ND BORN, AFTER HSIAO

Test	No	Birth order	Mean IQ	Sibling correlation	Chances in 100 that 1st born are inferior	
Stanford Binet	133	1st	102.8±1.3	56	100	(25 older 107)
	133	2nd	107.6±1.3			(25 younger 108)

Theodore Lentz (11), analyzing 4,000 siblings, ranging in age from six to 20 years, found the median IQ to be 97.9 and a median of 4.16 children in each family. His table follows (Table 14).

TABLE 14

No. siblings	Average IQ	No cases	Our figures (25 in each group)
0	107.9	415	105
1	105.6	865	107
2	101.5	772	103
3	97.4	689	108
4	94.3	516	97
10	83.9	25	79 (5 and over)
12 and over	79.9	15	

He concluded that there is a marked inverse relation between the *size of family and the IQ. He also concluded that there is a marked* decline in average IQ from one generation to the next, which he implies is due to this inverse relation. This is a very doubtful statement as data are lacking to prove that the IQ level changes from generation to generation. There is some evidence to support the concept that parents with low IQ's tend to have some children with mentalities slightly above their own.

Neil Dayton (6), investigating 10,455 retarded children in the Massachusetts public schools, reported more than half of them to be mental defectives (IQ below 70), but he found no significant correlation between the position in a family and the occurrence of feeblemindedness The families containing mental defectives were larger than those with other types of retarded children and were approximately twice as large as families having a college student or gifted child.

H E G. Sutherland (17) studied a group of 3,096 miners and their children in order to preserve a common social status and rule out the possibility that social status might be an influential factor in determining intelligence levels. He also noted, "negative correlation between intelligence and size of family even with the group whose fathers all follow one occupation and are of the same social status."

Crosby, Chapman and Wiggins (3), on the other hand, stated that there is a marked general trend for large families to be of inferior intelligence and social status

Most of the above studies dealt with several children in family groups and, therefore, are not exactly comparable with our study, but have definitely suggestive values. Our figures appear to support the theory that the younger child tends to have a higher IQ than the older The median IQ for our entire group was 105, which was equalled by the *only* child, exceeded by the *older* and *younger* groups, but was not reached by the *middle* child or the *youngest* child groups This suggests that the IQ tends to decrease with the increased number of siblings.

L. M. Terman (19) comments concerning his own and Cattell's cases of gifted children that, "in each case nearly three-fifths are first born"

The behavior problems of children have received their due amount of attention, and we have combined the results of several researches, for the purpose of a comparative study, in Table 15, in which reported occurrences of behavior are expressed as percentages A few references merit consideration in connection with Table 15.

Starch (16) wrote that, "The chief significance of the present results consists in further corroborating the notion that the mental make-ups of human beings is as much a matter of heredity as their physical make-ups and that environment plays a relatively small part

TABLE 15

BEHAVIOR PROBLEMS OF CHILDREN

All results translated into percentages of the groups

Behavior disorder	Wall (25)	Taylor (190)	Kawin (250) Problem 100	Kawin (250) Well adjusted 50	Kawin (250) Un-selected 100	Olson (35)	Wile (125)
Disobedience	56		33	26	27		7
Temper tantra	52	27	45	38	47		36
Food fads	52	17					24
Enuresis	44	45	31	16	23		22
Destructive	40	8	8	2	4		17
Restless sleep	36	6					
Masturbation	32	6	10	12	12	10	8
Domineering	28						
Hyperactivity	28	6	5		4		35
Quarreling	24						27
Nail biter	24	23	10	20	10	83	16
Jealousy	20	2					21
Willfulness	20						
Stealing	20	1	4		3		4
Whining	16		22	12	12		
Night terrors	16	14					10
Stubborn	12	21	34	16	24		28
Lying	12		2		2		
Frequent urination	12						
Dislikes duties	12						
Swears	12						7
Craftiness	12						
Finger sucking	8					20	
Unclean eating	8						
Truancy	8	1	2	2	2		1
Defecation	8						
Exhibition	8						
Greediness	8						
Sleep walking	4						
Vomiting	4			2	1		20
Stammering	4	8	7	10	8		14
Begging	4						
Voracious appetite	4						
Refusal to eat with family	4		33	28	27		24
No spunk	4						
Tic		11			5	6	11
Shy		7	7	5	6		9
Retardation		7	5		2		7
Idiocy		2					
Defective parents		9					
Pains		1					6
Over dependence on adults			17	2	2		11

in producing the resemblance of closely related individuals." He reached this conclusion upon the basis of achievement tests and their intersibling correlations. The correlation between the mental traits of brothers and sisters was approximately as high as that between their physical traits, and he found that this held true for traits not affected by school work, as well as for those directly influenced by school preparation As all the recent studies of heredity and environment point to their interaction and inseparability, this is hardly a startling conclusion

Blanche Weill (21) investigated 25 problem children between the ages of 2 and 12 years in 17 different families and listed the nature and frequency of their undesirable, or deviating, behaviors.

Marianna Taylor (18), reporting upon a group of 190 school children seen at the Boston Psychopathic Hospital, recorded their most prominent behavior problems in terms of frequency

Ethel Kawin (10) presents a thoughtful chapter on behavior and birth order In her group of 100 "problem" children from Chicago nursery schools, she observed that there was "a larger proportion of oldest children among the socially unadjusted children and a larger proportion of youngest children among the well-adjusted group than there are in the other groups" She noted that the most outstanding behavior disorders were those of "negativism" and "enuresis," but her groups of children were all under age seven. She compared three groups, a problem group, a well adjusted group and an unselected group.

W. C. Olson (15) took as his subjects 35 children from the first grades of the Minneapolis public schools (and 100 children from second grades whom we are ignoring because of their higher age) Using ten-minute periods of observation he found that Oral Habits (thumb sucking, nail biting, etc) were among the most frequent practices

Table 15, then, is a tabulation of these several studies, for purposes of comparison with our own results, regardless of the admitted difference in groups, ages, places, and conditions of observation

The outstanding differences in this table occur in the data from Weill and Olson, which is due mainly to the small number of cases which they studied and their subjective methods of observation. Kawin's data are the most comparable to ours, because of the size of our groups and because of a greater similarity in age range There is a wide distribution of behavior symptomatology in each study, which, making allowances for differences in nationality, education and background, suggests that the diversities of behavior are not primarily bound up in position in the family. The most outstanding similarities occur in temper tantra, enuresis, masturbation, nail biting, stubbornness, stammering, refusal to eat with the family, and shyness. Kawin's well adjusted group and unselected group provide a control and suggest that our group of 125 children were more destructive, hyperactive, over-dependent on adults than an unselected group would be, also that they were more susceptible to night terrors, vomiting and tics. Further comparison of the general results seems fruitless as this study primarily concerns birth order.

The difference in hyperactivity, however, is so great that it seemed wise to compare our findings with those of A. T. Childers (5), who studied 30 children from the Central Clinic in Cincinnati who presented hyperactivity.

TABLE 16

THIRTY HYPERACTIVE CHILDREN—CHILDERS

	No	%		Our cases
Ability higher than MA and general intelligence	3	10.0		
Ability lower than MA and general intelligence	11	36.7		
Ability equal to MA and general intelligence	11	36.7		
Unrecorded, undetermined	5	16.7		
Only child	11	36.7		48%
Oldest (but not only)	6	20.0	older	36%
Middle	6	20.0		20%
Youngest (but not only)	6	20.0	younger	24%
			youngest	40%

The differences in percentages as shown in Table 16, at least suggest that our group as a whole was not as extreme in hyperactivity as Kawin's figure might imply. It is proper to note that Childers' cases in each group were so few that his percentages have very doubtful statistical validity. We offer them merely as a basis of criticising our own percentages, which, while more valid, are not sufficiently accurate to warrant prediction in larger groups, or even groups differently constituted.

SUMMARY AND CONCLUSIONS

We have studied the behavior disorders of young children in terms of age, sex, intelligence, concomitant behavior and birth order. We have also compared our data with those of other investigators As a result, we have reached the following conclusions:

1 The Order of Birth in a family does not determine behavior characteristics, because fewer than 48 per cent of the children holding similar positions in like families exhibit the same behavior disorders.

2 The children studied evidenced no basic correlation between any two symptomatic behaviors Such a correlation would be expected, if Dr. Adler's theory of family constellation held true for any ordinal position.

3 The youngest child in a large family presents behaviors more similar to those of the only child than to those of the younger child in two child families The frequency of specific undesirable behavior reactions is considerably higher in the *only* child and the *youngest* child groups The *older* and *younger* in two-child families seem to present similar problems, but without the same frequency. Ordinal position shows no markedly definite influence

4. The intellectual potentials, computed by the Stanford Binet scale, were normal for all groups The *middle* child group had the lowest median IQ, of 97 The predominating symptom of the *middle* child group agreed closely with those of a group of 25 children with the lowest IQ's (all below 92). Several traits, as temper tantra, quarrels with others, restlessness, mother dresses and feeds, were as common among the low IQ group as among a group of 25 children with IQ's above 119 The low IQ group alone showed enuresis, retardation, unmanageability and speech defect among the first eight behaviors, while the high IQ group similarly revealed food fads, destructiveness, nail biting and quarrels with sibling.

5 Sex had no apparent consistent effect upon behavior patterns. Retardation was the only characteristic in which the difference between the sexes was as great as 16 per cent, and evidently the girls were interpretatively termed "retarded," because, factually, their median IQ was two points above that of the boys

6 Approximately twice as many boys were brought to the clinic as girls

7 There is considerable evidence that some forms of behavior are related to maturational levels rather than to ordinal position.

8 There is a tendency for IQ levels to decrease with rising ordinal position, with accompanying variations of behavior patterns

9 Our studies of the general occurrence of behavior disorders of young children indicate a very close agreement with the findings of Kawin

10 We found a negative correlation between the size of family and intelligence which is in agreement with Lentz, Dayton and Sutherland

11 Birth order does not determine behavior or personality characteristics, but the family constellation does provide a different environment for each individual. In specific cases this special environment may affect individual behavior disadvantageously, but birth order lacks the effect of a determinism

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AN EXPERIMENTAL STUDY OF THE DEFENSE MECHANISM IN THE OPOSSUM, WITH EMPHASIS ON NATURAL BEHAVIOR AND ITS RELATION TO MODE OF LIFE*[1]

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The avoiding or escape response in different animals has been studied *mainly with a single reaction system. Most of these have* employed the withdrawal of one of the legs away from a pain producing object. This procedure was used satisfactorily in experiments on the dog, sheep, and goat, by Liddell, James, and Anderson (3). In a later study (1) I found that this method was not adequate when dealing with a lower order of animals, such as the guinea pig. The flexion of the foreleg of the guinea pig could not be conditioned. From this we might be led to infer that the guinea pig is inferior to the other animals in its ability to become conditioned to dangerous objects. This is not true since the natural escape reaction from pain producing and dangerous objects for the guinea pig is to withdraw the entire body by running, and this response was easily conditioned. The cortical mechanism of the guinea pig is sufficient therefore to signal its natural modes of response, and it is only on this basis that this animal may be compared with those of different orders. The total situation, under conditions natural to the animal, is under observation rather than the general response to *an isolated adjustment.*

From this point of view it is interesting to consider the behaviors of animals of still lower orders than the guinea pig. Behavior phenomena and the significance of nervous development in evolution and mode of life can be understood only if emphasis be placed on natural reactions. In this report we deal with the behavior of the Virginia opossum. The opossum is largely nocturnal, while its principal habitat is the dark of caves and hollow trees. Among the many primitive forms of behavior which this animal exhibits, is an extremely passive defense reaction. When the opossum is surprised

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by a strange animal, instead of attempting to run away, it lies down, curls up, and remains motionless. It is difficult to imagine how such a reaction contributes to the survival of the animal. Is this behavior an extreme form of inhibition, the same general reaction as is observed in other animals to a less degree; or is it a special protective phenomenon peculiar to the opossum? What nervous or anatomical structures are correlated with this reaction which might help us to understand it? These questions cannot be answered until the animal's ability to defend itself and to escape from dangerous situations have been studied experimentally The present experiments are concerned with: *first,* the conditioned flexion of the foreleg to an electric shock; *second,* the total running response to an electric shock, and *third,* the passive defense and attack reaction.

EXPERIMENT I

In the study of the flexion response of the foreleg, the procedure was the same as that used in the experiment of the guinea pig (1) The animal was confined on a platform by a cord passing from the neck of the animal to a horizontal beam just above it (Figure 3). The hind legs were tied loosely to two pegs. By this arrangement the animal was free to move within limits but could not escape The flexion of the leg was recorded on a kymograph in an adjoining room. The breathing was recorded by a pneumograph of the type regularly used in experiments with the dog

When the front leg was shocked electrically, the foot was lifted and then replaced slowly There was no intense excitement or after discharge of excitation as observed in the sheep and dog A bell was sounded three seconds before the application of the shock After more than three hundred applications of the bell signal there were no indications of a conditioned leg reaction. There was some breathing response to the signal, but it may be definitely concluded that the foreleg reaction of the opossum cannot be conditioned (Figure 1).

EXPERIMENT II

In the second experiment the running response to an electric shock was observed. A two compartment box was used with an electric grill on the floor of one compartment The animal was free to escape into the second compartment when the current was applied to the grill. It was found that the opossum would not run off the grill

Fig I

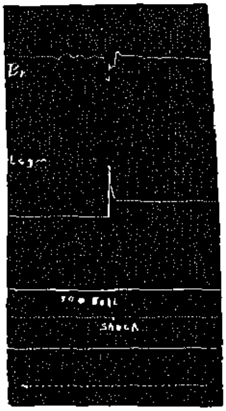

Fig II

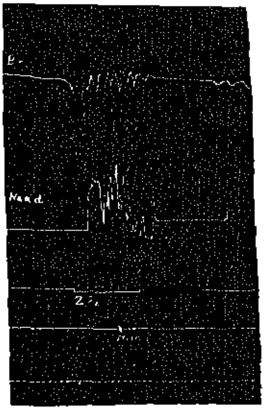

Figure 1 shows the behavior of the opossum after 300 applications of the bell and shock. The response of the leg occurs simultaneously with the shock although the bell precedes it by 8 seconds. Note that there is a conditioned breathing reaction. *Figure 11 shows the conditioned reaction of the head to the stick* on the second application of the buzzer. The head movement occurs to the buzzer rather then the stick.

Fig III

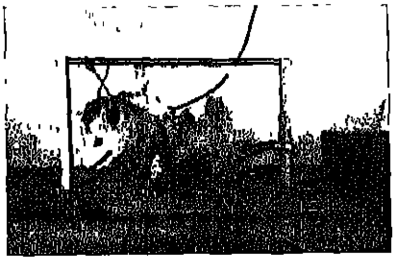

Figure 111 shows the opossum in the apparatus used in the first and third experiments. In the former the recording string was tied to the foreleg while in the latter the string was fastened to the head.

FIGURES 1-3

when shocked on the feet It would curl up and turn over on its side In this position the shock was avoided because the animal's fur coating provided insulation *Every effort was made to lead or push* the opossum toward the second compartment, but the animal never *of itself tried to escape If the opossum was held upright so that* the feet were shocked, its legs would be raised alternately in a slow forward movement, not at all the brisk running response shown by the guinea pig. The conclusion *is that the running reflex is unnecessary* as a means of escape when another form of response serves to protect the animal. The opossum does not resort to running as a mode of defense.

Further study has brought out another reaction. When one foreleg is shocked the opossum always turns his head toward this leg and holds the mouth wide open. Raising the leg and turning the head with open jaws seems to be a definitely composite or combined reaction. *When the animal was on the electric grill it would open* its mouth wide during the shock and at times would even bite at the walls of the box. The shock brought the animal out of the passive defense attitude which it ordinarily maintains and the biting reaction was exhibited as a basic behavior. There is a possibility that this behavior, together with the passive defense attitude, constitutes the chief protective responses of the opossum. A further effort was made to determine whether these reactions could be conditioned.

EXPERIMENT III

The simplest way to elicit the head and mouth reaction is to move a stick toward the head of the opossum. When the approach of the stick was signalled by a buzzer, the attack behavior became conditioned after only one application of the conditioned stimulus (Figure 2). A test was again made with the animals which had already been used on the grill and in the foreleg experiments, and in no case did they *give the running reaction or the flexion reflex.* The *attack* behavior is very easily conditioned, and is probably of high value as a survival reaction.

DISCUSSION AND CONCLUSIONS

In the present experiments withdrawal and escape as well as defense reactions of the opossum were studied. In order to compare this animal with others which have been studied, similar procedures were used. The experiments conclusively show that, with the opossum, the leg reaction to an electric shock cannot be conditioned. The animal could not even be taught to progress forward on an electric *grill. Thus withdrawal by running would* seem to be almost absent as a means of protecting this animal from pain producing objects.

Langworthy (2) the foreleg segments have a cor-
on early in the development of the opossum brain.
it is necessary that the forelegs become active early
n order that the immature young may crawl up to
rough these cortical centers are highly significant for
r life they lose their significance later in maturity
nd, the hind legs are not represented in the cortex
at all The low stage of segmental relation to the
act that the segments cannot be conditioned is prob-
neurological factors which predisposes the animal to
its An animal with the escape reaction in such a
elopment depends entirely on another form of avoid-
ion The well known "death feigning" or "opos-
ue avoidance which is effective in times of danger
y is within close range the opossum displays a strong
This attack reaction can be readily conditioned If
ng is merely an extreme form of inhibition, then it
derstand how the attack reaction can be so readily
is account the passive defense behavior seems rather
ve reaction correlated entirely with the inability of
run The animal feigns death in order to escape
able to escape by progressive movements, yet by be-
and still, it survives

als with peculiar modes of life, for protecting, avoid-
arefully studied, it is possible that the neurological
ich determine these modes of life could be specifically
ight be determined whether there are specific differ-
ure of the nervous phenomena or whether the differ-
ial organization The reptiles, for example, are slow
d assume fixed postures which may be held for hours
ow action and fixed posture in stalking their prey, yet
s near the reptile strikes swiftly These special modes
be correlated with a peculiar balance between exci-
ntory systems, or it may be that this nervous adjust-
of animals of a higher order but is expressed differ-
its anatomical make up Reptiles, like the opossum,
nners, therefore their peculiar modes of defense and
orrelated with an anatomical deficiency, or in other
action is directly influenced and determined by ana-

tomical development. In studying the reaction of these animals special attention also must be given to the environmental situation.

It should be emphasized that interpretation of conditioned reaction must take into account the nervous development of the animal, its anatomical construction, and the environmental aspect. Animals with a nervous system only in a low stage of development have certain reflex phenomena that are readily conditioned, and in such animals these reflexes are exhibited under all changes in the environment. *On the other hand, animals of a higher order may show variable responses* to the same stimulus or may give the same response to different stimuli. Animals of a lower order show a range of reflex action very limited in its nature. Such differences among animals must always be kept in mind in comparing the members of one group with another, as well as in drawing conclusions regarding the behavior of one species on the basis of knowledge derived from a different species.

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THE INNATE ORGANIZATION OF VISUAL ACTIVITY: I PERCEPTION OF FIGURES BY RATS REARED IN TOTAL DARKNESS*[1]

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The extent and even the existence of an innate organization of animal behavior has for a long time been a major problem for psychological theory. The recurrence of distinctive stereotyped modes of behavior in successive generations suggests that they are determined through heredity Such recurrent behavior, where the opportunity for its acquisition during the life of the individual is limited, has led to the conclusion that the behavior is determined by the developed structures of the central nervous system, and to the classification of the reactions as reflex and instinctive, implying racial rather than individual acquisition

On the other hand, a number of psychologists, chiefly of the behavioristic school (Holt, 1931, Kuo, 1932; Watson, 1919), have explicitly denied that there is, in mammals at least, any organization of behavior except that which is built up from random movements and the accompanying sensory excitations The first sensory excitations are regarded as irradiating widely in the central nervous system and later, when the individual reflexes become organized, as being concentrated upon specific groups of effectors From this viewpoint the development of function within the central nervous system is quite plastic, gross structural features may present limits to the development of behavior, but do not essentially determine the behavior itself It is held by these writers that even the early reflexes are a product of the peculiar environment of the embryo and developed by processes comparable with the learning of the adult organism

Field and experimental studies of invertebrates and sub-mammalian vertebrates (e g, Carmichael, 1927; Morgan, 1896; Weiss, 1926)

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have provided ample evidence to make such a position untenable for these lower forms With mammals, however, there has been little conclusive evidence on the question of innate organization of behavior, and that little chiefly concerning motor activity (Stone, 1934) The problem of the sensory organization corresponding to those motor patterns which are referred to as instinctive has been almost untouched. Such work as Stone's on the sexual and maternal behavior of rats, primarily studies of motor activity, implies of course some study of sensory organization, since the motor activity is frequently a discriminatory response. The stimulus patterns which elicit the response are of a limited range, though the limits are not yet clearly defined The innate motor organization then implies an innate sensory organization whose nature and extent are almost unknown

The Gestalt School, again, implies the innateness of certain organizations of the visual field, in stressing the dominance of primitive *Gestalten* over others established by training The evidence cited includes the persistence of visual illusions in spite of experience, and the failure of experimental subjects to pick out figures which they have been trained to recognize, when these form parts of more dominant figures (Koffka, 1935; Kohler, 1929)

Such an argument, however, cannot be altogether conclusive The dominance, at maturity, of certain types of visual *Gestalten* over others may itself be a resultant of the innumerable learning situations presented during growth, and not an inherent function of the central nervous system. The same objection applies to attempts to decide whether learning in the mature animal is determined by the relative or by the absolute properties of visual stimulation, and so to infer which is the more primitive mechanism (Warden and Rowley, 1929; Perkins and Wheeler, 1930)

There is thus very little direct evidence as to the extent of innate organization in the detail vision of mammals Lashley and Russell (1934) found discrimination of visual depths in rats reared to maturity in darkness. The clinical material presented by Senden (1932) on the vision of congenitally blind patients restored to sight after infancy is such as to make interpretation difficult. It establishes the fact that there is no recognition of even the simplest visual pattern (i e, there is no transfer from tactual to visual stimulation), but that there is, on the other hand, an immediate perception of difference between visual patterns This would *scarcely be possible if the first* visual activity were merely chaotic; it requires the assumption of some primitive organization of the field

"Innate organization" of vision, then, does not necessarily involve recognition of form, or the inheritance of conditioned responses The hypothesis might, perhaps, imply no more than a denial of chaos in the first sensory activity

Adult mammalian vision perceives patterns as coherent wholes segregated from their surroundings; objects as distinct from their backgrounds in tri-dimensional space, extents and intensities as relative to one another, and patterns as having form, an identity independent of extent These features of visual perception constitute its organization.

The theory that sensory organization is a product of conditioning implies that none of these features is to be found in vision at the first introduction to light Instead, according to the theory, there is only the excitation of a large number of independently active points There follows an indeterminate irradiation throughout the visual system, the transmission of excitation would become directed, according to the theory of conditioning, only by a repeated accompanying motor activity That is to say that tri-dimensional visual space, figure-ground relationships and size or intensity relationships must be so established; and since the conditioning of one receptor group has no effect upon neighboring receptors, each individual item in a series of intensities, for example, must be conditioned separately before its relationship to the rest of the series is perceived. So also *with the perception of space and of form*

The alternative nativistic hypothesis, on the other hand, has not such definite implications, but assumes that one or all of these things may be functions of the structure or physiology of the nervous system, independently of experience It is possible that an innate visual organization would vary at different phylogenetic levels With any one species therefore, the problem is to determine whether there is *an organization of the first visual activity, and* if so how many features such as the following it displays.

(1) The perception of the figure-ground relationship. some functional differentiation of part of the retinal excitation (the "figure") from the rest, determined perhaps by intensity differences, spatial distribution, movement, and so on

(2) The perception of directional order in series of intensities or sizes the *reaction to one intensity for example determined by its* value relative to other intensities, and the animal's discrimination not *of a particular gray, but of a gray brighter or darker than the rest* of the field.

(3). The perception of *tri-dimensional relationships* (Lashley and Russell, 1934).

(4). The perception of a common form in non-identical patterns or objects

(5). The immediate discrimination of certain forms forms, that is, which initiate distinctive modes of behavior, as is implied by such work as Stone's on the adequate stimuli to instinctive patterns of behavior

(6). The easier perception of some forms than others, or the *tendency of the visual field to fall into one figure-ground organization* rather than another

The experiments to be reported here concern (1) and (4) the perception of the figure, and of its form Albino and hooded rats were reared in total darkness, and tested at maturity The experiments were designed to discover if there was an immediate perception of the figure by these mammals, and some of the factors determining the perception, and secondly, to discover if the transfer of response to non-identical geometrical patterns occurs as it does in normally *reared animals*

A second paper will report an investigation of (3) · the transfer of response in size and brightness series. There is sufficient evidence for the transfer of response in mature animals normally reared in light, but we have to ask how far this may be a product of visual experience, of complex learning processes, rather than a fundamental property of the activity of the central nervous system

REARING

Albino and hooded rats were reared to maturity from the age of 6 to 8 days in a large ventilated light-tight box, which was itself within a dark room so that all light could be excluded while the box was opened At the beginning of the experiment panchromatic photographic plates were used to detect the entry of light into dark room, or dark box. One hour's exposure *in the dark room, and 40 minutes'* exposure in the dark box with the dark room lighted, failed to produce any detectable fogging of the exposed half of the plates.

Feeding and cleaning were then carried out in complete darkness The animals were fed bread and milk once a day, with meat, lettuce, and cod-liver oil once a week Although at maturity there were a number of rather small animals among the albinos, this appears to have been a fault of the stock from which they were taken and not of the rearing in darkness In general the rats were vigorous and *healthy at the beginning of training, the hooded animals uniformly* strong and well-developed

FIGURE-GROUND ORGANIZATION

Reports of first visual activity in congenitally blind patients (Senden, 1932) show that although they cannot describe or identify familiar objects or the simplest visual forms, they are quite able to perceive, in spite of a persistent nystagmus, a difference in the forms of two objects presented together. This implies that the objects are *seen as unified and distinct from the background What determines* the functional discreteness of part of the first retinal activity is a question that is quite unanswered.

The data supplied by the present experiments are of two kinds, the first consisting of incidental observations during the preliminary training in the discrimination of size and brightness (to be reported in another paper), the second consisting of the results of experiments dealing with responses to visual stimulation during the first few minutes of visual activity

A Incidental observations during training.

In planning the general form of these experiments, it was expected that much information would be supplied by the behavior of the animals at their first introduction to light, without setting up special *conditions of observation The animals were being trained in visual* discriminations by Lashley's jumping technique, in which the animal is taught first to walk from jumping to feeding platform along a narrow board, and later to make longer and longer steps until he has to hop across It was thought that observations during this teaching process would be sufficient to guide a further experimental study of the first perception of figures.

It was soon evident, however, that relatively little could be obtained by means of these incidental observations It is actually doubtful if any differences were to be observed between the behavior of the animals reared in complete darkness and that of animals reared in the usual conditions of alternating daylight and darkness Both groups were excited or nervous during their first training periods, the dark room animals possibly more so than the others, and in general the training conditions appeared to be almost as foreign to one group as to the other Neither had ever been out of their cages for any length of time, or required to maintain balance on narrow surfaces from which a fall was possible The insecurity of the animal's position on the jumping platform of Lashley's jumping stand, and in walking across to the feeding platform, had the effect of obscuring any differences in behavior that might otherwise have been found

Both dark room and normally reared animals were at first concerned only to cling as tightly as possible to the board on which they were placed, with no evidence during these first minutes of visual activity by either group of animals.

After walking across from one platform to the other some five or six times there was a change in behavior. The dark room animals had now a total visual experience of three to five minutes, and would reach out for support to any nearby surface and step across a gap beyond the reach of their vibrissae Since these nearby surfaces were constant in position, the reaction was not necessarily determined by vision, but may have been a purely tactual and kinaesthetic pattern Accuracy of direction, however, from different positions, and rapidity of acquisition, made the behavior appear less like a complex, learned process than a direct response to visual presentations There was no differentiation of horizontal or supporting from vertical or non-supporting surfaces: no recognition of "meaning," but an undiscriminating movement toward the nearest surface The visual activity determining such a response would be of the most primitive kind

Other evidence of some organization in the first visual activity is to be found in the performance of four animals whose training was begun with apparatus that was later found to be unsatisfactory They were trained to jump from a small circular platform on the top of a ringstand toward either of two open windows in an upright screen After the first three or four jumps to one window a "position habit" developed which was very difficult to overcome Rotation of the platform from which they jumped did not affect the habit; it appeared to be a purely visual preference, indicating a strongly established figure-ground organization after a total visual experience of possibly 20 minutes, or not more than a total three or four minutes of tactual and manipulative experience of the visual presentation.

Again, four others were presented with horizontal versus vertical striations after having made 30 jumps to an open versus a closed window They took somewhat longer to jump, but nevertheless did so spontaneously, at the first presentation of these completely new patterns The jumps were clearly directed toward the centres of the unfamiliar cards Under other circumstances one might say that the cards toward which the animals looked were conditioned stimuli determining the direction of the jumping, but here the animals had had no experience of the diagrams to which they were reacting, and it must be concluded that the response was determined by the surroundings—by the *place* of the cards, not by the cards themselves This appears to be the functioning of the figure-ground relationship in a tri-dimensional pattern. Further, the diagrams themselves appeared to be organized for some of the animals at this first presentation. one rat made one error only in the first 10 trials, while another made 8 errors in 10 trials, definitely preferring the vertical striations in spite of irregular alternation of the two cards and repeated failure to find food,

Such incidental observations, however, can at most establish that there is the figure-ground relationship in the first visual activity Further experiments were necessary to obtain any information as to how the relationship is established, or how it functions

B *Experiments during the first minutes of vision*

Two methods of study were available: first, observation of behavior in circumstances designed to reveal selective responses to parts of the visual field, and secondly, the use of formal training in visual discrimination Each method has definite disadvantages. The observation of behavior in a free field permits few repetitions, since it is impossible to know when learning begins to have an effect, with training, on the other hand, the animal is being tested *after* his first visual experience, and the training must therefore be made as short as possible

In spite of these disadvantages of method, it was thought worth while to observe the behavior of the rat in controlled conditions during the first few moments of his visual experience These experiments were incidental to the study of transfer of response with geometrical figures (reported below), they were not a systematic investigation, but rather a survey intended to reveal any striking feature of the behavior The incidental observations already reported had failed to suggest definite methods of investigation, and it was felt that the 28 animals available could better be used in such a survey than in a single experiment which might or might not afford conclusive results. The animals were therefore divided into 4 groups of 7 each; with these it was found possible, planning the later experiments of the series on the basis of the results obtained in earlier ones, to obtain information upon three questions: (1) Has the rat any *innate preference for black as against white?* (2) *Will he respond* selectively, at the first introduction to light, to a differentiated region within a uniform ground? (3) Will his first visually conditioned response be disturbed by a reversal of brightness gradient between the object and the field, that is, is a white object in a black field functionally equivalent to a black object in a white field?

Experiment 1. Black-white preference

Method. The animal was introduced to light in the centre of a free field enclosed by a barrier half white, half black, and permitted to move in the field until he reached some part of the barrier A record was made of the segment of the barrier reached by the animal—that is, whether he chose white or black

TABLE 1
NUMBER OF ANIMALS CHOOSING BLACK OR WHITE IN 2 TRIALS AT THE FIRST INTRODUCTION TO LIGHT

1st trial:	black	white	2nd trial:	black	white	total:	black	white
	6	1		4	1[1]		10	2

[1] Choices of five animals given only in the second test, one not tested, one choosing neither black nor white

The barrier was half of black, half of a light-gray cardboard 11 inches high, making a circular enclosure of 44 inch diameter on a waxed black circular table. The sole source of light was a 15-watt lamp hung 10 inches above the centre of the table. The table could be rotated, interchanging black and white

The seven animals were first tested without changing the positions of black and white, the table was then rotated through 180 degrees, and the animals re-tested

Results The results are presented in Table 1. It will be seen that in both trials one animal only chose white Since the rats were not numbered, the experimenter could not know if this one was the same on each trial By an error one animal was not given the second test Also, on the second test one animal chose neither black nor white but the dividing line between them, and is not included in the table The number of animals reported on the first test, therefore, is seven, on the second five.

Similar tests with (*a*) a 20-degree segment of white in an otherwise black barrier, (*b*) a similar black segment in a white barrier and (*c*) a black box, subtending an angle of 30 degrees at the centre of the table, against a white barrier, gave less conclusive results, but again showed a slight preference for black A second group of animals, exposed to light for the first time, were used, and were given one run with each of the white and black segments, and two runs with the black box The results were (*a*) No animal chose the white segment; (*b*) 2 of 7 animals chose the black segment, and in each of these tests the probability that one run will be to the differentiated segment is 1/18 (*c*) Three of 14 runs were to the black box against the white barrier; chance, 1/12, or about one contact in 14 runs. The choices of black in these tests are more frequent than chance, though not significantly so; but taken with the total of 10 choices of black in 12 trials on the first test makes a preference for black, in the experimental conditions described, statistically probable One may at least conclude that there was no preference for white. This conclusion is important for the interpretation of Experiment 2b (below), in which a preference was found for a more complex pattern of black and white, as against a black background.

Experiment 2a. Investigation of a figure.

This and the following experiment (2*b*) suffered particularly from the disadvantages of method already mentioned. No training could be used, since the purpose was to discover if the visual presentation is organized at the moment of first stimulation In the observation of behavior it was very difficult to determine the point at which the behavior began to be affected by experience

Method The experiment sought to discover if the animal, put in an uncomfortable position, would in his attempts to escape orient himself toward a distinctively marked object, or attempt to reach it. For this purpose the rat was placed on a small circular platform *at the top of a ringstand*, the platform was 3 inches in diameter, small enough to make the rat feel insecure To prevent his attempting to slide down the upright upon which the platform was placed, a tubular hood of black velveteen was attached all round the edge of the circular platform, and extended downward enclosing the upright for a distance of 5 inches

The second platform, placed just beyond vibrissae reach, subtended an angle of 60 degrees, and was distinctively marked by the addition of a 6-inch square of black cardboard to which was gummed a white ring of inner diameter 2 inches, outer diameter 4 inches. The background was a screen of black cotton, rising from the floor to a point 10 inches above the animal, forming a square enclosure 3x3 feet

Seven animals, already tested in Experiment 1, were used The fact that these animals had already been visually stimulated may have been responsible for the negative results obtained This is improbable, however, since the two situations were so dissimilar.

Each animal was tested once only, but with different animals the direction of the second or "goal" platform was varied in three positions—East, North, and West from the animal. An electric fan directed a current of air over the animal from the South, so that it was improbable that any odor of the second platform could reach him The noise of the fan also constituted a "sound screen" helping to minimize the effects of extraneous noise.

Light was provided by a 15-watt lamp hung 10 inches above the animal, and screened to cast light only within the enclosure The animal was taken from his cage in complete darkness and placed on the small stand. The light was turned on for a period of 180 to 205 seconds, and the time recorded (by means of a stop watch) which the animal spent oriented toward the goal platform

Results The results were negative; approximately a chance proportion of the total time was spent facing the goal platform A total time of 1310 seconds was spent by seven animals on the stand, of this time 175 seconds was spent oriented toward the goal platform. This is approximately 1/7, or a little less than the 1/6 called for by chance

The range of the times spent by individual rats facing the goal platform was from 10 to 45 seconds, the average 25 seconds The behavior did not suggest any selective response to the goal platform, to the noise of the electric fan, or in any other direction There was no attempt to climb off the platform upon which they were placed, but only a rather constant change in direction of orientation

Experiment 2b Investigation of a figure

Method A second experiment with the same purpose was set up, using this time the open field method The goal platform differentiated by a white ring on a black ground, already described, was set at the edge of a black waxed circular table of diameter 48 inches. Beside this was placed a white object about 2 inches square swinging slowly through a 10 to 12 inch arc one inch above the level of the table A 15-watt lamp 12 inches above the centre of the table lighted figure and table clearly, and left the background dark.

Seven animals were introduced to light for the first time. Each was given two tests; in the first the figure was at the East side of the table, in the second at the West side An electric fan, South, directed a current of air across the table to eliminate olfactory cues from the figures or the experimenter

The rat was removed from his cage in complete darkness and placed in the centre of the table, oriented at right angles to the direction of the figures The light was turned on and left until the animal had moved from the starting position to the edge of the table, when the light was again turned off and the animal returned to a cage in the dark box When the dark box had been closed, a record was made of the approximate movements of the animal, and of the part of the table's circumference at which he had arrived—that is, if he chose the figure or rejected it The figure subtended at the centre of the table an angle of approximately 60 degrees, or 1/6 of the circumference, so that chance selection would mean that two of the 14 runs would be to the figure

The animals had been numbered before the experiment, and could thus be identified in the second trial

Results. One animal did not move in either trial, but remained motionless in the centre of the table for more than 3 minutes, after which the test was discontinued One animal ran away from the figure both times, the remaining five selected it in both runs The time for each run ranged from 5 to 20 seconds

Such a degree of consistency in behavior suggested that the position of the experimenter might have influenced the runs Repetition of the experiment, with a group of animals used in Experiment 1, gave these results. 1st run, 4 of 7 to the figure, 2nd run, no choice of the figure. This total of 4 in 14 runs is higher than chance, though not significantly; and the difference, as compared with the first group's performance, may be discounted, owing to the fact that the animals of the second group (those with a total of 4 choices of the figure) had already been used in an open field experiment Their performance on the first run, with 4 of 7 to the figure, contrasts sharply with that on the second run, with none choosing the figure.

Taken together, the performances of the two groups give evidence of a preference for the differentiated region of the figure.

Discussion The question as to whether this preference indicates a perception of the "figure" as such, as unified and distinct from its surroundings, is difficult to answer. Several points here deserve comment The lighting of the table was so arranged that the background, though not homogeneous, was much darker than the figure itself. The figure was composed of two parts. (*a*) a moving white object, and (*b*) a white ring on a black surface. It was clear, in observing the animals' behavior, that there was no tendency to select either part of the figure; the runs were most frequently near the centre of the figure, rather than to moving or stationary object There was no evidence then of the perception of two objects or figures

It seems very improbable that the region in which the complex figure was could have been chosen because of the elements composing it. The region was differentiated from the background in that (*a*) it contained white areas, which had (*b*) steeper intensity gradients between black and white than other intensity gradients of the rest of the field, (*c*) one of the white areas was in motion and finally (*d*) the objects composing the figure were distinct tri-dimensionally from their surroundings The last of these, (*d*), need scarcely be considered, since it is improbable that the difference in visual depth would be effective before the objects are seen as unified, if they are so perceived, the figure-ground relationship is organized. It is also unlikely that either (*a*) or (*b*), white areas with steep intensity gradients between black and white, determined the preference of the rats for the figure since both factors were present and ineffective in the black-white preference tests of Experiment 1. In that experiment, there was evidence of a preference for a large or small black segment, but none for a white segment, of an encircling barrier (*c*) The motion of one part of the figure may be dismissed as an independently decisive factor because in the behavior of the animals there was no indication of a preference for the region in which the motion occurred

Such reasoning points definitely away from the constituent parts of the preferred figure, and toward its properties as a whole in the determination of the preference It is not clear that this means the perception of a unified figure, although the figure as a whole appears to have been perceived as something other than an aggregation of the constituent elements This perception, since it occurs in the first 30 or 40 seconds of visual experience, is independent of any conditioning process, i e., is innately determined

Physiologically, the functioning of the visual system must be such that the activity aroused by part of the field (the "figure") is segregated in some way from other activity in the system The factors involved are obscure Rubin's work (1921) has shown the existence of phenomena which are difficult to bring into relation with physiological events, especially since it is not known at what neural levels the processes occur The most relevant physiological material is that obtained from the study of visual defects resulting from head wounds (Kluver, 1927), and particularly Poppelreuter's (1923) analysis of the various levels of visual organization in these patients There is no evident relation, however, between this kind of detective vision and the vision of congenitally blind patients restored to sight (Senden, 1932)

Experiment 3 Functional equivalence of black and white

Method Seven animals which had had no visual experience were first trained, in complete darkness, to find and cross to a platform at a distance of 5 inches, they were then given the same problem in light. During this training the goal platform was white, the background uniformly black, when the rat had learned to find the second platform by means of visual cues, he was given a black platform with a white background, to discover if his response would be disturbed by the reversal of the brightness gradient between figure and ground

The starting platform was circular, of 3-inch diameter, and black The goal platform during training was of unpainted white pine, upon which was placed a white food dish The background during training was a black cotton screen rising from the floor to a point 10 inches above the animal, making a square enclosure 3x3 feet In the test, the goal platform was painted a flat black, and had no food or food dish upon it The background in the test was a light-colored wrapping paper

Light was supplied by a 15-watt lamp 10 inches above the rat and shaded to cast light within the square enclosure only

During the preliminary training in darkness, the goal platform was a distance of 5 inches Throughout training and testing it was varied in three directions, East, North, and West from the starting platform. An electric fan, South, prevented olfactory cues At this distance the animals could readily find and cross to the second platform in complete darkness

In the first day's training with light it was found necessary not to increase the distance of the goal platform, as had been planned Three trials only were given On the second and succeeding days six trials were given, with the goal platform at a distance of 6 inches. At this distance the rat could find it with his vibrissae only by making a definite effort in the right direction.

On the fourth day, although some animals had not completely learned to use visual cues only, the test was given: the white goal platform replaced by a black platform without food dish, and the black surrounding screen replaced by a similarly arranged white one

An error in both training and test trials was defined as any stretching out, as if to cross to the goal, in a wrong direction This was not a clear-cut criterion, so that much doubtful behavior had to be scored as errors The error score is therefore probably higher than it should have been

Results. The results are presented in Table 2 The table includes an estimate of the maximum visual experience involved in each of the three training periods: 6, 6 and 3 minutes respectively Rat and experimenter were both in complete darkness except in the actual choice periods, and a more exact time record would have added undue complications to the experimental procedure The estimates are for the slowest rat each day, and like the error scores are probably higher than the reality It is improbable that any except one animal, No 5, had a total visual experience of more than 8 minutes before the test.

TABLE 2

R OF ERRORS MADE BY 7 RATS REARED IN DARKNESS, IN LEARNING TO
EP TO A WHITE PLATFORM AND TESTED WITH A BLACK PLATFORM

1st day (3 trials, 5 min max'm)	2nd day (6 trials, 5 min max'm)	3rd day (6 trials, 3 min max'm)	Test (6 trials)
3	4	1	0
3	5	2	4
3	4	0	0
3	1	0	0
3	2	2	4
2	0	2	1
2	3	1	3
19 errors 21 trials	19 errors 42 trials	8 errors 42 trials	12 errors 42 trials

e number of errors made on the first day, a total of 19 in 21
means a total failure of the animals to use the visual presenta-
n the search for the goal platform They had been trained in
ess to step across a gap to food, if, as is suggested by Experiment
iere is an immediate perception of the figure as such, one might
expected the rat when first given visual cues to investigate the
differentiated part of the visual field, and therefore to make
rrors But although the error score may be too high, the ex-
enter saw no suggestion of a selective response to the goal
rm.

e rapid learning, however, shown in the decrease of total errors,
19 in 21 trials to 8 in 42 trials, suggests that the failure of the
minative response was not due to a lack of visual perception, but
ack of relationship, for the rat, between visual perception and
arch for food.

e test scores show that Nos 1, 3 and 4 made no errors in the
l trials. The behavior of these three was clearcut they crossed
tly, without investigatory activity, and showed no disturbance
e *change of brightness relations between figure and ground*
) made one error only, if this one is included, 4 of 7 animals
erred their responses to the new conditions

hould also be noted that one animal, No 5, after repeated errors
ining, failed to find the goal in the first test trial, and had to be
d to it

Discussion The conclusion from Experiment 2b, that the figure-ground organization is to be found in the first visual activity, is further supported by the rapid learning in Experiment 3 If the organization were the result of a learning process, one would scarcely expect it to occur in a visual experience of eight minutes or less, with only 13 presentations. The experiment shows, further, evidence that the determination of the response was something of the nature of the figure-ground relationship rather than any specific stimulus The conditioning was not merely a conditioning to a focus of retinal excitation; for in the critical trials, the response conditioned to a white (stimulating) object is evoked by a black (relatively non-stimulating) object A stimulus-response formula might correlate the response conditioned in training to the retinal excitation caused by the white figure. But when all the retina is excited except a region similar to the formerly excited one, *the response is determined by the small unexcited region,* not by the part of the retina which is now excited

It may be concluded that the response was determined not by a specific retinal excitation, but by a differentiation between a region of excitation and the surrounding, less excited, retinal field, for subsequently the response was evoked by the same region when less excited than the surrounding field.

Summary. To summarize the results of the experiments with the first moments of visual activity The choice of a complex black and white figure, against a black ground (Exp. 2), in spite of a preference for black as against white (Exp 1), the immediate learning to respond to white against black and the subsequent spontaneous transfer of response to black against white, are comprehensible on the assumption that the first visual perception is of an object differentiated from its background, but are with some difficulty accounted for by the theory of sensory organization through conditioning.

Discrimination of Geometrical Patterns

At the present stage of development of psychological theory, one of the principal problems presented by the discrimination of patterns lies in the fact that a discrimination established between two specific patterns will be immediately extended to certain other pairs of patterns As with the figure-ground organization, it is of great interest to know what part is played by experience in this transfer of response. Lashley (1934) has pointed out that the response of the mature animal is apparently not to the precise pattern of receptor cells stimulated but to a property of the pattern that may be called its form, and has in unpublished experiments made an extensive study of the rat's transfer of response in the visual discrimination of geometrical patterns. The problem of the present experiments was to determine if previous visual experience is necessary to the transfer, in other words, to determine whether the behavior, in transfer situations, *of the rat reared in darkness is like that of the rat normally reared* in light.

Method and Apparatus. Eighteen animals which had been reared in darkness, as already described, were trained in pattern discriminations by the jumping technique devised by Lashley and described in detail by Gulliksen (1932). (*A*) Fourteen of these animals were trained in a fully lighted room; before training they were brought from the dark room and allowed to become light-adapted in deep narrow boxes open only at the top, and painted a flat black. When the training period was over they were returned to the dark room until the following day. (*B*) The remaining four animals were trained in the dark room. They were placed upon the jumping platform in complete darkness. The light was turned on until the rat jumped, and turned off while he ate, or in case of an error, while he was being returned to the jumping platform. Thus this group, as a check upon the performances of the animals trained in full lighting, were exposed to light only while they were on the jumping platform and had no opportunity to explore a visually presented environment.

(*A*). The jumping stand used in full lighting was a slight modification of that used by Lashley. It had a wooden instead of a glass top, was lined over the top and sides with black velveteen, and lighted from inside by two 7½-watt lamps one on either side of the jumping platform. The feeding platform was enclosed by 6-inch walls, upon which the rat was not permitted to climb, and which prevented him from seeing the surrounding room.

(*B*). The jumping stand used in the dark room had a glass top which extended far enough in each direction that the rat could not, by standing up, reach its edge. No other surface was near enough to be touched by the rat while he was on the jumping platform. The platform itself was circular, of 3-inch diameter, which is small enough to make it difficult for the rat to see the surface upon which he is placed. A black velveteen hood was attached round the edge of the platform and extended downward five inches concealing the upright to which the platform was fastened The top of the platform was covered with black velveteen; this, with the hood concealing the upright, made a virtually homogeneous surface. Because of the smallness of the platform, the visible edges of this surface for the rat would be always behind and below him and difficult to explore tactually The actual edge of the platform, upon which his forefeet rested, would be because of the continuity of velveteen covering and hood not visually distinct for the rat. The lighting of this apparatus was from a 15-watt lamp placed behind and above the animal The position taken by the rat preparatory to jumping was sufficient warning to enable the experimenter to switch off the light before the rat landed on the feeding platform

In the usual training procedure, which was followed with those animals (*A*) trained in full lighting, the rat is permitted to walk across a board laid from jumping to feeding platforms, and then made to step across longer and longer gaps In these preliminary steps, the animal obtains an extensive experience with both visual and tactual aspects of the objects and surfaces about him For the animals to be trained in the dark room (*B*), such extensive visual experience was to be avoided, and it was found possible after some initial difficulties to train the animals to jump in complete darkness Their visual experience therefore began after they had become accustomed to the jumping stand, and their first jumps in the light were made to white (positive) and black (negative) cards.

The training of Group *B*, therefore, is a control of incidental learning of "form" during the training period, and the performance of this group, which had no opportunity for simultaneous tactile and visual exploration of surfaces, is to be compared with the performances of the group trained in full lighting

Attempts to control other factors which might account for discrimination of patterns are to be found in the patterns which were used, and in the training and test sequences When both groups had learned a black-white discrimination, they were trained to discriminate horizontal from vertical striations (*A*, Figure 1) of ¾-inch width They were then tested with various combinations of the horizontal-vertical diagrams (*B, C, D, E*) of Figure 1 When the criterion of learning, 20 correct errorless trials, was attained, the animal was

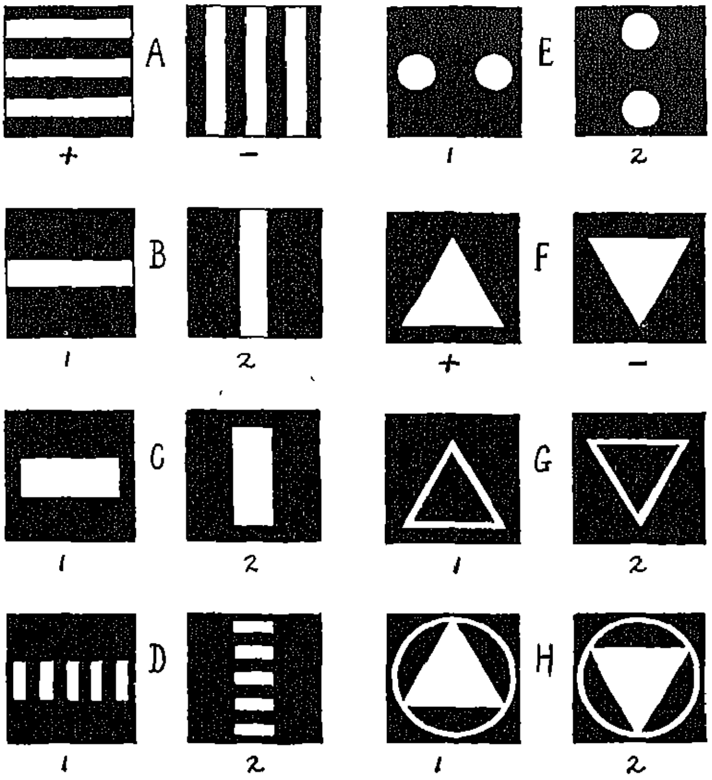

FIGURE 1

The diagrams are reproductions to scale of 5x5 inch stimulus cards used in training and testing the animals reared in darkness. The striations, *A*, were used in training, the horizontal positive, the vertical negative. The solid triangles, *F*, were also used in training, the upright positive, the inverted negative. The other pairs of diagrams were used in tests for transfer, the numbers 1 and 2 distinguish the individual cards in Tables 3, 4 and 5

immediately given 10 test trials, on the next day, 10 retraining trials with the training stimuli (Diagram *A*), and a second 10 test trials, making a total of 20 test trials in which a choice of either of the test stimuli was rewarded.

Diagrams *D* and *E* were designed to test the possibility that transfer, in horizontal-vertical discriminations, might be explained by eye-movements and the following of visual contours. With Diagram *E* there is no possibility of discrimination by either a following of contours or perception of vertical elements, with Diagram *D*, the horizontal mass of *D* 1 has actually three times as much vertical as horizontal contour, and vice versa for *D* 2 Diagrams *B* and *C* involve some test of the importance of identical elements in transfer The single stripes of *B* 1 and *B* 2 are identical with the individual striations of the training cards, *A*; the rectangles of *C* 1 and *C* 2, however, are twice this width, and the horizontal rectangle, therefore, has almost as many elements identical with the card bearing vertical striations as that bearing the horizontal (*A* 1 and *A* 2). A test of transfer from *A* to *C*, though not conclusive, is to some extent a test of importance of identical elements.

Following these tests, the animals were trained to discriminate the erect and inverted triangles of Diagram *F*, and tested with the outlines of similar triangles (*G*) and triangles circumscribed by circles (*H*) The details of training and tests follow:

(1) The group trained in the dark room were trained with striations (*A*), tested with rectangles (*C*), and composite rectangles (*D*); trained with solid triangles (*F*), tested with outlines of triangles (*G*) and circumscribed triangles (*H*) (Table 3).

TABLE 3

TRAINING AND TEST RECORDS OF 4 ANIMALS REARED IN DARKNESS AND TRAINED WITH LIGHTING CONTROL

The letters *A* to *H* refer to the diagrams of Figure 1 *A*, trials to learn striations, *C*1, *C*2, *D*1, *D*2, number of responses to each of 4 diagrams in 2 transfer tests, *F*, trials to learn solid triangles, *G*1, *G*2, *H*1, *H*2, number of responses to each of 4 diagrams in 2 transfer tests

Rat No	A	C1	C2	D1	D2	F	G1	G2	H1	H2
8	160	11	9	10	10					
9	140	14	6	*4*	*16*	90	*19*	*1*	11	9
11	190	*16*	*4*	10	10	90	*18*	*2*	*18*	*2*
12	90	*17*	*3*	*4*	*16*	70	*20*	*0*	*16*	*4*

(2). Half the group trained in full lighting were trained with striations (*A*), tested with rectangles (*C*), and were then trained with the same diagrams, the horizontal rectangle positive They were then further tested with composite rectangles (*D*) and with horizontal and vertical pairs of circles (*E*). Lastly they were trained with solid triangles (*F*) and tested with outlines (*G*) and circumscribed triangles (*H*) (Table 4)

TABLE 4

Training and Test Records of Seven Animals Reared in Darkness and Trained without Lighting Control

The letters *A* to *H* refer to Figure 1 *A*, trials to learn striations, *C*1, *C*2, number of responses to each of 2 diagrams in transfer test, *C*, trials to learn rectangles, *D*1, *D*2, *E*1, *E*2, number of responses to each of 4 diagrams in 2 transfer tests, *F*, trials to learn solid triangles; *G*1, *G*2, *H*1, *H*2, number of responses to each of 4 diagrams in 2 transfer tests.

Rat No	A	C1	C2	C	D1	D2	E1	E2	F	G1	G2	H1	H2
1	90	*15*	*5*	60	12	8	14	6	130	*20*	*0*	11	9
2	100	11	9	30	*18*	*2*	13	7	130	*18*	*2*	14	6
3	160	11	9	50	*17*	*3*	11	9	100	14	6	10	10
4	160	12	8	30	10	10	*17*	*3*	130	10	10	10	10
5	*180*	9	11										
6	40	11	9	40			*20*	*0*	70	*19*	*1*	*18*	*2*
7	110	14	6	50	10	10	*9*	*1*[1]					

[1] No 7 had 10 trials only with diagrams *E*1 and *E*2

(3) The second half of the animals trained in light were trained with striations (*A*), tested with single horizontal and vertical striations (*B*), with composite rectangles (*D*) and with horizontal and vertical pairs of circles (*E*) (Table 5).

TABLE 5

Training and Test Records of Seven Animals Reared in Darkness and Trained without Lighting Control

The letters *A* to *E* refer to Figure 1 *A*, trials to learn striations, *B*1, *B*2, *D*1, *D*2, *E*1, *E*2, number of responses to each of 6 diagrams in 3 transfer tests

Rat No	A	B1	B2	D1	D2	E1	E2
13	130	9	11	10	10		
14	90	*17*	*3*	14	6	13	7
15	170	*18*	*2*	10	10		
16	70	*20*	*0*	10	10	10	10
17	100	14	6	10	10	10	10
18	90	*18*	*2*	11	9	10	10
19	60	*18*	*2*	10	10	10	10

Results and Discussion. Tables 3, 4 and 5 present the results of the tests In each the individual tests, distinguished by the letters of Figure 1, are given in the order in which they were presented to the animals. For each pair of diagrams, the number of choices of each single diagram is given, the left (in Figure 1) first

Assuming that 15 choices of one pattern in 20 test trials is sufficiently above chance to be significant, it will be seen that all significant scores for each group are in the same direction—i e , indicate a preference for the same diagram In summarizing the tabular material for discussion, this trend will be regarded as showing transfer of response to the preferred diagram

(1). The group trained in the dark room transferred to the plain horizontal rectangle (*C* 1), to the composite vertical rectangle (*D* 2) , with triangles, to the outline (*G* 1) and to the circumscribed triangle (*H* 1) (Table 3).

(2). The first group trained in full lighting transferred to the plain horizontal rectangle (*C* 1), and then, after further training with these diagrams (*C* 1 and *C* 2), to the composite horizontal rectangle (*D* 1) and the horizontal pair of circles (*E* 1), with triangles, to the outline (*G* 1) and the circumscribed triangle (*H* 1) (Table 4)

(3) The second group trained in full lighting transferred to the horizontal stripe (*B* 1), but to neither composite rectangles (*D*) nor to pairs of circles (*E*), although with both the only deviations from a completely chance score are toward the horizontal mass (*D* 1 or *E* 1) (Table 5).

The significance of these data may be discussed in the light of three possible explanations of the pattern discrimination: (*A*) discrimination of visual form is established by the simultaneous tactual and visual investigation of objects, (*B*) it is determined by proprioception from eye-movements in following the contours of the patterns, and (*C*) it is determined by identical elements in the patterns

A Tactual experience of visual presentation The performance of the animals trained in the dark room, with no opportunity for simultaneous tactual and visual exploration of objects, does not differ greatly from that of the groups trained in full lighting, as far as the test sequences are comparable Their transfer to outlines of triangles and circumscribed triangles (Table 3) is rather more consistent than that of the other group (Table 4), though this is probably a chance variation, since there is no reason why this group should do better That they did no worse, however, is important; it may be concluded that no incidental learning, or incidental visual experience of other than the training cards, is the basis of the transferred responses If it were, the animals trained with a drastic limitation of visual experience should, if they show transfer at all, show it to a less extent than those trained in full lighting

B Eye-movements and visual contours It may be seen from Table 4 that animals trained with striations (*A*) and plain rectangles (*C*) transferred to the horizontal mass (*D* 1), with the composite rectangles, rather than to the horizontal contours of the vertical mass (*D* 2), with the horizontal and vertical pairs of circles, the horizontal pair (*E* 1) was preferred, although there was no question of either horizontal or vertical contour

The animals trained in the dark room, however, transferred to the horizontal elements of the vertical mass (*D* 2) with the composite rectangles The explanation is probably to be found in the different preliminary training The animals which transferred to the horizontal mass (*D* 1, Table 4) had been trained with the plain rectangles (*C*), before being tested with the composite rectangles (*D*); those trained in the dark room had not This interpretation is supported by the data of Table 5 These animals, like those trained in the dark room, did not have the interpolated training with rectangles and showed no significant transfer to the composite rectangles.

C Identical elements in transfer If the transfer to the composite rectangles (*D*) is due to the interpolated training with plain rectangulars (*C*), an obvious explanation suggests itself, that the transfer occurs when there are identical elements in training and test diagrams This would account for the transfer with triangles as well as much of the horizontal-vertical discrimination.

Opposed to this explanation, however, is the transfer from striations (*A*) to plain rectangles (*C*) (Tables 3 and 4) The number of identical elements between horizontal rectangle and vertical striations would vary with different fixation points, but in any case would not be greatly less than the number of identical elements in horizontal rectangle and horizontal striations The difficulty for the explanation is that there are too many identical elements Again, the data of Table 5 show that after training with striations alone there are three departures from chance scores in tests with composite rectangles (*D*) and with circles (*E*); all three are toward a preference for the horizontal mass, although identical elements would play a very minor role in the discrimination

There is not, then, definitely conclusive evidence that the discrimination is independent of identical elements, but such a conclusion seems very probable It is probable, that is, that in the discrimination there is a perception of form as such

The question of form presents some difficulty If it is innately determined—that is, if first visual activity includes the perception of form, as appears to be established for man since there is immediate discrimination of form differences (Senden, 1932)—we are confronted with the problem of its physiological determination, a problem *closely related to that of the figure-ground* relationship, already discussed If the perception of form by rats is a product of experience and conditioning, it is difficult to see how this could take place in the conditions of the present experiment, and particularly with the group trained in the dark room. The possibility that horizontal and vertical were discriminated by proprioception from eye-movements has already been dismissed. There appears to have been, for the dark room group at least, no possibility of any other symbolic process distinguishing horizontal from vertical masses, or erect from inverted triangles For the animals in the dark room, no visible contour could be manipulated · there was no simultaneous seeing and touching of straight lines, and hence no possibility that the visually horizontal would be conditioned to one reflex movement, the visually vertical to *another, thus distinguishing them.*

It is not, therefore, established by these experiments that there is a perception of form in the first visual activity in the rat; but the results of the experiments, including that part dealing with the figure-ground relationship, make such a conclusion probable and rule out the possibility that the organization of visually perceived patterns occurs either through a visual following of contours or through the manipulation of seen objects

CONCLUSIONS

From the earlier experiments of this paper, dealing with the figure-ground relationship, and the perceptions of the first few minutes of visual activity, it may be concluded that:

(1) *There is an immediate* perception of a differentiated figure, apart from the perception of its elements.

(2) The response to this is primarily not to an elemental excitation, but to a region of differentiation which is indifferently greater or less intense than the surrounding field

From the investigation of transfer of response with geometrical patterns, it is concluded that

(3). Transfer of response with the discrimination of geometrical patterns is not affected by the rearing in darkness, or thereafter by an extreme limitation of visual experience during training

4) Transfer of response is not due to a following of visual contours with the eye, nor to the operation of any other symbolic process established by the manipulation of seen objects

During the course of this paper reference has been made to the neural processes underlying the visual perceptions of the rats. The inferences made have been opposed to the theory of sensory organization by conditioning, but the data of these experiments do not justify any detailed inferences as to neural mechanisms. Experiments to be reported in a second paper concerning transfer of response in the discrimination of size and brightness will permit some discussion of underlying mechanisms.

SUMMARY

Twenty-eight hooded and albino rats were reared to maturity in total darkness. Two series of experiments were carried out, investigating (*a*) the organization of the visual figure-ground relationship in the first few minutes of visual experience, and (*b*) transfer of response in the discrimination of geometrical patterns after formal training with Lashley's jumping technique

Open field experiments at the time of the animals' first introduction to light showed (*a*) evidence of a preference for the darker half of the field, (*b*) evidence of a preference for a visually differentiated region, and (*c*) an immediate transfer of response, conditioned to a white object against a black field, to a black object against a white field

Experiments with pattern discriminations revealed the same kind of transfer of response as that found by Lashley with normally reared animals.

It is concluded that in the rat the figure-ground organization and the perception of identity in such geometrical patterns as the solid triangle, outline of triangle, and triangle circumscribed by a circle are innately determined Discussion of the implications of the data for neural theory is postponed until a following paper, but it is argued that the first conditioning is not to the excitation of any specific receptors but to a region of differentiation

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FACTORS INFLUENCING THE SOCIAL ADJUSTMENT OF CHILDREN OF PRESCHOOL AGE*

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During the preschool period the child is beginning to be socially active He soon learns that certain needs are satisfied best by social activities and that his happiness and well-being are dependent upon his ability to understand and adjust to other people Social adjustment is not a passive process Its development follows much the same progression that is found in all phases of behavior Anderson (1) says· "The behavior of the adult toward persons has its genesis in the behavior of the child toward persons" Behavior patterns are established early in life. "It is now generally recognized" writes Young (11), "that one's major characteristics of personality are usually determined before one is five years old, and some writers say as early as two or three"

While most writers agree that the preschool period is the golden age for forming habits of social adjustment, few studies have attempted to analyze the factors which influence such adjustment. Tilson (10) studied some of the problems which arose in the care and training of 225 American born children, (110 boys and 115 girls), ages one to five years referred to seven habit clinics, whose records furnished the data for the study The problems treated in the clinics were physical, social, and emotional in nature

The relation between problems and the chronological and mental ages of the children, the educational training, religion and occupation of the parents, home rating, and the number of children and their age position in the family were studied Her findings show that the problem child is found at all ages from one to five years, at all mental levels, with all types of parents, in all kinds of homes, in all sizes of families, and in all age positions in the family Some data, however, appeared to be far more significant than others as indicating factors associated with maladjustment, e g , disagreement

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between parents about discipline, friction between parents, nagging attitudes toward the child and tendencies to compare him unfavorably with others, inconsistent and lax discipline, bribery and deception, over-solitude, lack of a "sense of responsibility" for training the child and "tension" between mother and child

Kawin (5) analyzed the case records from the Preschool Department of the Institute of Juvenile Research of the Department of Public Welfare of the State of Illinois. The major objective of her study was

> To discover what relationships, if any, exist between the social behavior of the child from two to seven years of age, and various other data that had been recorded about the child and his environment In order to determine whether certain items are factors affecting the social adjustment of a child, these possible factors as found in a group of socially "unadjusted" children were compared with similar data as found in a group of "well-adjusted" children and in an "unselected" group which served as a further control

Group *A*, the problem group,[1] consisted of 100 children who presented problems of social adjustment in their relationships to other children Group *B*, the well-adjusted group, consisted of 50 children who were considered to be well adjusted to other children. Group *C*, the unselected group, consisted of 100 unselected cases from the files of the Preschool Department

Of the 19 items studied in Kawin's investigation, the only factors which appeared to be significantly related to the social adjustment of a young child were the intelligence of the child, the occupation of the father, the relationship of the father to the child and his attitudes toward the child, and the agreement of the parents in regard to child-training

The studies of Tilson and Kawin which have been very briefly and inadequately summarized afforded the stimulus for the present study. The major objective of this study was an attempt to determine some factors that appear to differentiate the socially adjusted from the socially unadjusted child of preschool age. The study is limited in the number of cases with the intent of making it intensive rather than extensive While similar in some respects to Kawin's investigation, no attempt was made to duplicate either the problem or the procedure The problem is far more limited and the small number of cases does not justify drawing any general conclusions. It has been possible, however, to eliminate some of the difficulties encountered by Kawin as a result of her larger number of cases and the difficulty of securing complete and adequate data for all subjects The data in the present study also should be more uniform and consistent since all the workers learned to know each child and his parents intimately and there was marked continuity in the group of workers. The value of the study lies chiefly in comparing the findings with those of other similar studies

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[1] The use of the expression "problem group" or "problem child" may well be questioned. As used throughout this study it refers to children who presented difficult problems for their parents and other adults who were in charge of their care and training

The subjects used for the investigation were 25 children ranging in age from two to five years when the study was started They were enrolled in a Federal Emergency Relief Administration nursery school which was conducted with the cooperation of the University of Wyoming during the school year, 1934-1935 The nursery school was housed in a suitable six room cottage which was in good condition It had a large sunny yard with excellent drainage The nursery school was supplied with adequate furnishings and play equipment The staff consisted of the head teacher who was a graduate student in psychology with several years of experience in special education, a trained nurse, a dietitian who was a graduate of the department of home economics, a clerical worker, several student assistants, and the writer who was the supervisor of the nursery school [2]

The children were at the nursery school from 8:30 A M. until 4:00 P. M five days a week A typical nursery school schedule was followed. A wholesome atmosphere prevailed. Every effort was made to provide opportunity for adequate social and personal adjustment

Before any child was enrolled, he was given a thorough physical examination by a competent physician, and a brief case history was taken by a trained social worker. During the first two months a careful case study was made of each child by the students enrolled in a course of mental hygiene, the head teacher, the nurse, the dietition, and the supervisor Every student cooperating in the study spent at least five hours per week assisting at the nursery school No student was assigned more than two children for observation and intensive study Informal meetings were held once a month with the mothers, the staff and the student assistants to give an opportunity for all to become acquainted and to discuss general and individual problems The topics to be discussed were determined by the major problems which had presented themselves for consideration during the month, e g, prevention of colds and contagious diseases, diet, temper tantrums, enuresis, etc

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[2] Members of the staff and students who cooperated in the study were Maude Sholty, Eileen Goodall, Marguerite Johnson, Dorothy Fitch, Katherine Foruna, Harry Frederick, Florenece Gates, Kathleen Gould, Charlotte Hayes, Elizabeth Howard, Jo MacDonald, Betty Miller, Martha Omenson, Ruth Shipman, Mary Ethel Smith, Barbara Vickere and Mavis Wyland

The study was continued during the winter quarter by the same group of workers who were enrolled for a course in the psychology of preschool children Each child was given two individual intelligence tests by trained examiners The tests used were the Stanford Revision of the Binet Tests and the Rhode Island Intelligence test for the older children, and the Kuhlman-Binet and the Minnesota Preschool Test for the younger children A third test was used when there was marked discrepancy in the results of the first two tests

The language behavior of each child in a controlled situation was tested using the technique outlined by Goodenough and Anderson (3) The child was placed in a familiar environment After sufficient preliminary conversation to insure freedom of response, the experimenter showed the child a number of interesting toys and picture books as suggested by McCarthy (8) After the first toy was shown, every verbal response or expressive vocalization was recorded verbatim until 50 consecutive responses were secured The child was addressed as little as possible during the observation since the aim was to secure spontaneous responses A quantitative analysis was made of the individual records, i e, mean length of sentence, number of different words used, and the time required to secure 50 responses

The rating scale devised by L. R Marston (7) was used to secure a measure of a tendency toward introversion or extroversion Three trained students who had assisted regularly at the nursery school for periods of from 12 to 20 weeks, and the three members of the staff: the head teacher, the nurse, and the dietitian rated each child independently on the 20 items in the scale. To insure uniform situations all the raters observed each child in four different situations as suggested by Marston (7) (*a*) social resistance to the approaches of a stranger, (*b*) compliance with the experimenter's request to perform a difficult task, (*c*) interest in a novel environment, and (*d*) self-assertion in attempting to secure a preferred toy All children were rated on one trait only at a given time to avoid the influence of the "halo effect" in so far as possible The correlation of the individual raters with the average of the raters varied from 0 86± 04 to 0 94± 01.

Every home was rated on the Sims Scale for Socio-Economic Status The case histories were amplified by three students who were majoring in sociology and enrolled for a course in social case work Further data on home background, marital relation of parents, relationship of parents to child, agreement between parents in child training, the number of children in the family, the child's position among his siblings and other miscellaneous data were secured

After the children had been in attendance at the nursery school from three to five months they were classified into three groups the well adjusted socially, the mediumly well adjusted, and the poorly adjusted Since there is no general agreement among workers as to what constitutes social adjustment and since few norms for social behavior have been established for any age level, investigators in the field are confronted with many difficulties Consequently the working definitions which Kawin established, arbitrarily, for her study were utilized Kawin (5) states

> In the absence of any definite criteria, as to what constitute problems of social adjustment, for the purpose of this study a child was considered to present such problems when, in the opinion of more than one adult in charge of him, (parents, teachers, Infant Welfare workers, and members of the staff of the institute) difficulties in entering into satisfactory relationship with other children were considered characteristic of the child over a period of several weeks, months, or years A child who merely felt ill at ease during the first week or two of a new school or other new group experience, but then adjusted

satisfactorily to other children, was not included in the problem group. Difficulties in entering into satisfactory relationships with other children included a variety of behavior reactions ranging from aggressiveness, pugnaciousness and persistent unwillingness to share toys, to shyness, aloofness, and indifference.

For the present study the classification into three groups was based on the composite results secured by the head teacher, the social worker, a student assistant, and the supervisor who checked each child independently on Kawin's statements in regard to the child's social adjustment. The immaturity of social behavior of preschool children and age differences in the stages of social adjustment in children ranging in age from two to five years as stressed by Blatz, Millichamp, and Fletcher (2) were kept in mind constantly in checking the children.

Sample statements from Kawin (5) on which each type of adjustment was based are as follows.

I Statements Indicating Poor Social Adjustment
Frequently or Usually
Is domineering, bossy, aggressive, rides rough shod over others. Is not happy in school. Does not talk to other children or adults.

II Statements Indicating Neither Poor Nor Good Social Adjustment
Plays neither exclusively alone nor freely with whole group. Equally cooperative and uncooperative. Somewhat domineering and bossy. Children merely accept her; neither like nor dislike her.

III Statements Indicating Good Social Adjustment
Usually
Is sociable, friendly, likes other children. Gets on well, plays well with other children. Enjoys school. Cooperates, works, plays with others. Good sense of fair play.

On the basis of such statements by the four workers concerning the children, only four of the 25 children were classified in Group *A*, the poorly adjusted group, 13 children were in Group *B*, the mediumly well adjusted, and eight children in Group *C*, the well adjusted socially. There was marked agreement between the raters in classifying the children. Unanimity of opinion was obtained without difficulty after a discussion of the child in the few cases where disagreements were found. The data were then compiled for each of the three groups to facilitate comparisons. While the data for all studies, viz., intelligence tests, language test, introversion-extroversion, socio-economic status of the home, case histories, etc., were analyzed in great detail only a brief summary of some of the findings which may bear some relation to social adjustment are discussed in this report (Table 1). The groups were too small to

TABLE 1

A BRIEF SUMMARY OF THE RESULTS OF SOME OF THE STUDIES CARRIED ON AT THE FEDERAL EMERGENCY RELIEF ADMINISTRATION NURSERY SCHOOL CONDUCTED WITH THE COOPERATION OF THE UNIVERSITY OF WYOMING, LARAMIE, WYOMING, 1934-35

Group	A		B		C	
I Sex	Number	%	Number	%	Number	%
Boys	3	75	5	38	4	50
Girls	1	25	8	62	4	50
Total	4	100	13	100	8	100
II Chronological Age						
Range	3-7 to 4-5		2-3 to 4-5		2-5 to 5-1	
Mean	4-1		3-3		3-5	
III Mental Age						
Range	3-6 to 4-6		2-4 to 5-8		2-10 to 5-6	
Mean	4-0		3-4		3-4	
IV Intelligence Quotient						
Range	89 to 101		87 to 131		89 to 117	
Mean	97		104		104	
V Physical Condition	Above Average		Below Average		Average	
VI No. of Children per Family	4.0		3.2		3.3	
VII Introversion-Extroversion						
Range	31.2 to 91.6		38.5 to 87.5		40.3 to 83.3	
Mean	63.3		61.6		64.7	
VIII Language Behavior						
Length of sentence in words						
Range	0 to 4.5		0 to 4.5		1.3 to 6.0	
Mean	2.6		2.8		3.2	
No. of different words used						
Range	0 to 111		0 to 106		26 to 133	
Mean	60.8		57.4		62.1	
Time required (minutes)						
Range	10 to 25		4 to 23		7 to 19	
Mean	18		9.8		11.1	
IX Position among Siblings	Number	%	Number	%	Number	%
Only	1	25	2	15	2	25
Oldest	0	0	1	8	0	0
Middle*	3	75	4	31	2	25
Youngest	0	0	6	46	4	50

TABLE 1 (continued)

A BRIEF SUMMARY OF THE RESULTS OF SOME OF THE STUDIES CARRIED ON AT THE FEDERAL EMERGENCY RELIEF ADMINISTRATION NURSERY SCHOOL CONDUCTED WITH THE COOPERATION OF THE UNIVERSITY OF WYOMING, LARAMIE, WYOMING, 1934-35

Group	A		B		C	
	Number	%	Number	%	Number	%
X Parentage						
Native born	3	75	11	85	8	100
Foreign born	1	25	2	15	0	0
XI Age of Parents						
Mother 20-29	0	0	10	77	3	37.5
30-39	3	75	3	23	5	62.5
40-49	1	25	0	0	0	0
Father 20-29	0	0	4	31	2	25
30-39	2	50	7	53	4	50
40-49	2	50	1	8	2	25
50-59	0	0	1	8	0	0
XII Education of Parents**						
Mother Grade school	3	75	9	69	3	37.5
High school	1	25	3	23	5	62.5
College	0	0	1	8	0	0
Father Grade school	4	100	9	69	6	75
High school	0	0	4	31	2	25
College	0	0	0	0	0	0
XIII Socio-Economic Status	11.5		11.5		11.3	
XIV Occupation of Father						
I—Professions	0	0	0	0	0	0
II—Business	0	0	0	0	0	0
III—Skilled Laborers	1	25	2	15	3	37.5
IV—Semi-skilled Laborers	2	50	4	30	3	37.5
V—Unskilled Laborers	1	25	7	54	2	25
XV Marital Relationship of Parents						
Normal	3	75	10	77	4	50
Broken Home	1	25	3	23	4	50
XVI Agreement of Parents on Child Training						
Satisfactory	1	25	6	46	8	100
Conflicting	3	75	7	54	0	0
XVII Relationship of Father to Child						
Good	2	50	2	15	3	37.5
Fair	0	0	6	46	1	12.5
Poor	2	50	1	8	0	
No Father	0	0	4	30	4	50.0

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*A child is designated as a "middle" child if he occupied any intermediate position in a family of three or more.

**Grade school education indicates merely that the parent did not go to school beyond the eighth grade. Some parents completed only the fifth or the sixth grade. Likewise high school does not imply graduation. Most of these parents spent only one or two years in high school.

justify determining statistically the significance of the differences found, or to draw any general conclusions as previously stated. However, the findings will be compared with those of Kawin and other studies. Tilson gives no data on many of the items included in this study, consequently few comparisons were possible with her findings.

The present study shows the highest percentage of boys in the *problem group. Kawin found the three groups to be about equal* as to sex.

It is interesting to note that the lowest mean IQ is found in the *problem group which also agrees with the findings* of Kawin and several other workers. Only four children in the entire group tested above average (above 110) in intelligence. The three highest are in Group *B* which is neither poorly nor well adjusted. Hollingworth (4) has stressed the difficulty that children who are more intelligent than their group, encounter in their social relationships.

The results of the intelligence tests tend to verify another finding of Kawin and of most other psychologists who have tested preschool children, the tendency of the Stanford-Binet Scale to rate children *too high at the early age levels. Although most of the children* came from very inferior homes as rated by the Sims Scale, less than one-third of the children tested below 100 and only three below 90 in intelligence. While agreeing in a general way, the intelligence quotients on the Minnesota Preschool Tests were lower than those secured from the Stanford-Binet Scale for most of the cases tested.

The physical condition of the child was found not to be a significant factor with these children. Kawin's finding indicates a slight but rather consistent tendency for the problem group to be in *poorer physical condition than either of the other groups.* The problem group in this study was a little above average physically while the other two groups were average or below. Taken as a whole the groups were considered as very little below average for physical condition as rated by a local physician who examined each child before he was enrolled.

A slightly larger number of children per family was found in the poorly adjusted group. Kawin found the three groups to be about equal in this respect.

Marston considers scores above 60 on the introversion-extroversion scale, which are based upon the average ratings of several competent judges, as indicative of a tendency toward extroversion and a score below 50 as tending toward the introverted type. All three of the groups have a mean of the ratings slightly above 60. Most studies of preschool children have shown a tendency toward the extroverted type. The mean rating is slightly higher for the well-adjusted group and the range is larger for the poorly adjusted children as might well be expected. The tendency toward extroversion or introversion was not investigated either by Kawin or Tilson.

The mean number of words per sentence shows a slight increase from Group *A* to the well-adjusted group and the range too is larger. The range and mean of the number of different words used is greater also for the well-adjusted group, and yet more time was required to elicit the responses from the poorly-adjusted children even though the mean chronological and mental ages were higher than in either of the other groups.

As found by Kawin neither the only nor the youngest children presented more problems than do other children. In the present study both the only and the youngest children appear to be slightly better adjusted. Kawin found the largest percentage of oldest children in the problem group and the largest percentage of youngest among the well-adjusted children.

Only three children came from homes of foreign parentage. None *of these were in the well-adjusted group. Kawin found no significant* differences among the three groups in regard to the national origin of the fathers.

Both studies agree in finding the parents slightly older in the poorly adjusted group.

More mothers of the well-adjusted group had attended high school from one to four years than in either of the other groups, however, the child of the one mother who had a college degree was in Group *B*. No differences were found with regard to the education of the fathers. The large majority of the fathers had completed only the eighth grade or less while a majority of the mothers had spent from one to four years in high school. Kawin's data are incomplete on this point, but no differences were found between the groups for the cases where such data were available in her study.

Since the subjects included in this investigation were a very narrowly selected group, drawn for the most part from homes of inferior social status and from unskilled or semi-skilled laborers, the data with regard to the occupation of the fathers and the Sims rating for social status do not show significant differences However, the findings tend to agree with Kawin in that the highest occupational ratings are found in Group *C*

The largest percentage of well-adjusted children came from broken homes, the result of divorce or desertion This fact is contrary to the findings of most studies One half of the well-adjusted children had never known their fathers or had known them for only a very short time at best Consequently, the figures for the agreement of parents on child training and for the relationship of the father to the child are inadequate. Both Kawin and Tilson found these factors to be somewhat significant Some workers have found that a broken home may be more conducive to wholesome adjustment than a home marked by dissension and tension. It is highly probable that such was the case with these children As a result of the unemployment and the straitened financial conditions of most of the parents, few if any of the homes were normal Unusual emotional stress and many types of maladjustment characterized most of the homes.

Most of the data secured were quite objective and the results were compiled and the comparisons made on a numerical basis even though the numbers were too small for statistical treatment of the results Such factual data are fairly dependable Some of the information, however, is relatively subjective and the dependability and reliability are low The findings may well be questioned

Kawin says,

> The social adjustment of a young child to other children outside his own family does not appear to be so conspicuously related to any other single factor in the child's own make up or environment that the one can be said to be the "cause" of the other What this study does indicate is that there are a group of factors which appear to be related to the child's social adjustment
>
> Such groupings of factors are sometime called constellations, and this concept is coming to play an increasingly important role in psychological explanations of behavior and personality Recent studies in this field tend more and more to support the viewpoint that any particular manifestation of behavior or personal-

> ity is not the result of any single factor in the make up, environment, or experience of an individual, but is rather a result of a constellation of such factors which, in combination with each other, tend to produce the observed results

In discussing the influence of environmental forces in development, Lewin states, "Particular features of the environment are usually less important than *its total character in determining its effect on the child's development*" The conclusion reached by Lois B Murphy and Gardner Murphy in summarizing their discussion of the responses of children in social situations also stresses the whole situation rather than individual stimuli They state, "Social psychologists are feeling their way towards a new formulation of their problem, in which less emphasis will be placed upon isolated stimuli and responses and more upon functionally significant whole situations and upon the dynamics of the behavior of whole organisms"

The present rather intensive study of a small group of children tends to point to the same general conclusions. No single factor either biological or environmental shows a marked relationship to the child's social adjustment An evaluation of any one or all of the objective factors which have influenced the child is inadequate unless we know how these conditions have affected his personality and how they have affected the attitudes toward the problems of life which he had developed Pernicious influences do not always have a detrimental effect, they may actually prove beneficial by fostering more wholesome attitudes It would seem then that social adjustment is largely a matter of integration, the result of the total situation—the unity of elements which has influenced the development of the child

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A STUDY OF RACIAL DIFFERENCES IN EIDETIC IMAGERY OF PRESCHOOL CHILDREN[*]

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The investigation to be reported is an experimental study to determine the incidence of eidetic ability in white, Mexican, and Negro children from three to six years of age

The present study combines two major problems for investigation in the field of eidetic imagery The first problem is that of determining the frequency and strength of eidetic ability in preschool children. The second problem is concerned with a comparison of this eidetic incidence and quality in white, Mexican, and Negro preschool children.

NATURE OF EIDETIC PHENOMENA

Before going into the procedure of this study, an attempt will be made to define the eidetic phenomenon, and review the literature pertaining to the subject

According to E. R Jaensch's definition (10), eidetic images occupy an intermediate position between sensations and images. They resemble after-images in the sense that they are literally seen; they resemble memory images in the sense that they are rich in detail and possess a certain degree of motility. The eidetic individual is able to project his image, which is perceptual in character The image appears just as real to him as if his senses were actually being externally stimulated. This subjective phenomenon may be found in the visual, auditory, tactile, and olfactory fields The present study is concerned with visual images only

Urbantschitsch (30) seems to have been the first to carry on an experimental investigation of eidetic images In 1907 he published a book on optic "Anschauungsbilder" in which he distinguished between the "ordinary visual memory image," and the "perceptual memory image" The latter is considered an eidetic image. The most extensive studies in the field of visuaul eidetic imagery have

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been carried on by E R Jaensch (10) and his students in the Marburg Institute of Psychology. Kluver (12) has reviewed the work of the Marburg school

Jaensch and his students have concentrated their studies of eidetic ability around its relation to typology Jaensch found that two types of images always appear with any group of individuals tested for eidetic ability. These types of images correspond, he believes, to relative constitutional types of personalities One type, which he terms the "*T*" type because, in an exaggerated form, the subject suffers from tetany, has eidetic images which resemble after-images. Eidetic images secured by persons of the "*T*" type are usually difficult to produce, complementary in color and fragmentary in appearance. The "*B*" type of personality, so termed, because, in its exaggerated form, the subject has Basedow's or Grave's disease, experiences eidetic images which are rich in detail, positively colored, and which appear as a whole Most eidetic images are a combination of some qualities from each type. Jaensch points out that the ability to have eidetic images tends to disappear with puberty, and that it is chiefly a childhood phenomenon Jaensch credits children with the possession of, what he terms, a "unitary type" of eidetic image in which many of the qualities of the after-image are to be found.

INVESTIGATIONS WITH YOUNG CHILDREN

The experimental literature pertaining to investigations of eidetic *ability in very young children is extremely limited* Roessler (27) examined children from six to ten years of age He seems to have been very successful in adapting the methods of Jaensch to the examination of the six-year-old child. On the whole, investigators generally accept Roessler's six-year-old age level as the peak in frequency of eidetic ability Observations of eidetic ability in individual preschool children have been reported Downey (6) reported the spontaneous eidetic imagery of a four-year-old boy Antipoff (3) observed eidetic ability in her seven-year-old son. Révész (26) demonstrated that preschool children are highly capable of accurate observations in after-images Kiesow (33), and Gatti and Vacino (32) used six-year-old children in their investigations with after-images

Peck and Walling (23) have been the only experimenters in the United States to report carrying on a systematic investigation of eidetic ability with preschool children. They examined 20 children from two to five-and-one-half years of age in a preliminary study. The study was designed to work out a technique adaptable for testing eidetic ability of preschool children. They tested the reliability of the technique by noting the consistency with which the two parts of the test distinguished between the eidetic and the non-eidetic subjects, and by correlating the ranking of the eidetic subjects in the first test series and their ranking in the second test series. The strength of eidetic images may be determined by using either duration of time or number of details as a criterion. Tripp (29) suggests that a good criterion for the true eidetic image is abundance and richness of detail, which in most cases far exceed a memory image. Peck and Walling used both duration of images and number of details in ranking their subjects. In testing for reliability of technique, they found rather high correlations between these two methods of determining the strength of eidetic images. They obtained a correlation of .95± .02 between these two methods in the first test series, and in the second test series they found a correlation of .88± .04. When number of details was used as the criterion for ranking the eidetic subjects, they obtained a correlation between the first test series and the second of .75± .09. They also obtained a correlation of .48± .16 between the two test series when duration of images was used as a criterion. They found that 50 per cent of the 20 children reported eidetic images. The same 10 subjects that reported eidetic images in the first test series reported them in the second test. The writers are indebted to this investigation for testing materials and technique. The technique used is based upon that used by Jaensch (10), Kluver (14), and Teasdale (28).

Racial and National Differences

There have been very few investigations in regard to racial or national differences in eidetic ability. These few investigations have been carried on with children above the preschool age level. Kluver found no racial differences in studying the eidetic imagery of Italian, Jewish, and Negro school children in the United States (14). These results are contrary to what Jaensch expected. Jaensch believes that racial differences exist.

Meenes (20) tested 100 Negro school children. He found 34 per cent to be eidetic. This is possibly a little higher percentage than that of the white children, which is generally accepted as approximately 30 per cent. O'Neill (22) found that 30 per cent of 260 boys possessed some eidetic ability Brother Rogatus Kearney (11) examined 296 boys from 9 to 15 years of age. These boys were of English, German, Italian, Irish, and Polish parentage Fifty per cent of those of German parentage, 45 per cent of those of English descent, 36 per cent of the Italian boys, 22 per cent of the Irish, and 18 per cent of the Polish boys were found to be eidetic

SUMMARY OF LITERATURE

Jaensch was the first to raise the question of the existence of racial differences in eidetic ability. The few experiments which have been done in this field up to date have been carried on with adults or children above the preschool age level The results of these experiments indicate some slight difference among children of various nationalities in the incidence of eidetic ability None of the experimenters in this field have studied the differences in characteristics of eidetic images among the various races

PURPOSE OF EXPERIMENT

The purpose of the present experiment was to determine the incidence of eidetic ability in white, Mexican, and Negro preschool children. More specifically, the purpose was to compare these three groups with regard to number of visual eidetic images, richness of detail, and duration of images, using a technique adaptable to preschool children.

SUBJECTS

The subjects used in this study were 208 white children, 50 Mexican children, and 50 Negro children from three to six years of age. The 208 white children were members of various nursery schools, public schools, and kindergartens, or were secured through the activities of the Parent-Teacher Association of Austin, Texas. A number of the Mexican children were members of a preschool language class of Bickler school, Austin, Texas The others were brought to the school by their older brothers and sisters or through the activities of the Parent-Teacher Association. The Negro children were, for the most part, members of a colored Emergency Relief Nursery School A few others were given the tests in their homes All of the subjects, with the exception of a small number of white children, were members of the same locality, Austin, Texas A few white subjects were secured from kindergartens at San Antonio, Texas, and Houston, Texas

EXAMINERS

Several groups of examiners were formed to work together to secure the data used The examiners for the white children included Dr. Leigh Peck, Miss Rosemary Walling, Mrs. Lois Bradfield, Miss Jennie Marie Goodwin, Miss Faye Jackson, and Mrs. Amelia Barthlome Hodges. The examiners for the Mexican subjects included Beatrice Arichiga, a young Mexican girl, Mrs. Lois Bradfield, Miss Jennie Marie Goodwin, and Mrs Hodges The three last named examiners also knew Spanish The testing of the Negro children was done by Miss Faye Jackson and Mrs. Hodges

As suggested above, Dr Leigh Peck and Miss Rosemary Walling worked out the technique for testing which was used. The other examiners, with the exception of the young Mexican girl, were students in the Educational Psychology Department of the University of Texas and were trained in the technique of testing by Dr Peck and Miss Walling In preliminary practice, Dr Peck and Miss Walling supervised each group of examiners in administering the tests Further reliability of the examiners was determined by checking the record blanks secured from this preliminary practice to determine uniformity in recording

PROCEDURE

The subjects were tested individually in a quiet environment In most cases the subjects were seated at a low table in a familiar room with medium daylight coming over the left shoulder In some instances, where the examiners tested the children at their homes, the porch was used so that the maximum amount of light might be secured No head rest was used The child was seated in a comfortable chair across the table from the examiner. The examiner held the stimulus pictures or placed them on a rack about 15 inches from the subject The record keeper sat to the back or beside the child, and recorded the subject's responses The time was taken with a stop watch, and recorded on the blank

MATERIALS

The pictures used for the eidetic testing were all of the silhouette type Silhouettes were used, because, as Jaensch has pointed out, they appeal more strongly to what he calls the "physiological component" These silhouettes were designed for the study by Mrs Alice Ward Nichols of the Art Department of The University Junior High School, Austin, Texas The silhouettes were drawn on thick white drawing cards 11¼ x 7 inches The projection screen of heavy dark grey paper was of the same dimensions The stimulus pictures included:

I Tests for after-images

1 Red disc, two inches in diameter with a black dot in the center, to be fixated 20 seconds

2 Two-and-one-half inch black silhouette of a bear with a white eye and black pupil, to be fixated 20 seconds

II Tests for eidetic imagery

1 Black silhouette of a boy holding a fish in one hand and a fishing pole in the other, water, a bush with a rabbit behind it, grass, and a tall tree with a bird on the lowest limb, to be examined without fixation for 30 seconds

2 Silhouette in black, pink, and yellow of a circus scene, in foreground little girl holding pink balloon, little boy walking with a circus whip in his hand, in the background balloon man with balloons standing by his sale booth, a trainer driving three elephants, white circus tent with three flags waving, a boy, and a pink circus wagon with two clowns beside it, to be examined without fixation for 30 seconds

3 Black silhouette of children going to school, in the foreground little girl and little boy walking, one little boy running, a little boy sitting by a road sign waving his hand, in the background a little girl pulling a wagon with a child occupant, a building, the schoolhouse, children playing, one child swinging, a well and bucket, and some trees, to be examined without fixation 30 seconds.

All of the silhouettes appealed to the interests of preschool children

DIRECTIONS TO SUBJECTS

The children were invited to the examination "to look at pictures." In some instances when the subject was not known to the examiner a short period of play or conversation was engaged in before the examiner began the test Before beginning the test the examiner attempted to explain to the child the possibility of seeing things that were not really there Such a question as "Do you know that sometimes we can see things that are not really there?—just think of them so hard that we see them?" would arouse the child's interest, and give him an understanding of what was required If the child's answer was negative to the first question, the examiner continued,

> Maybe you could learn Wouldn't that be fun? I am going to show you a picture, and if you will look at it very hard, you can still see it after I take it away. You can see it right here (the examiner pointed to the projection screen) if you will look at it very hard all the time I am showing it to you It may be some other color, but you will see it

The examiner placed the first picture for testing for after-images upon the stand, and said,

> Here is a picture of a red ball Look right at the dot in the middle of it Don't look at anything else Just look hard at the dot as long as I show you the picture

(The stimulus picture was removed after 20 seconds) The examiner asked,

> Now can you see anything? What do you see? What color is it? Can you put your finger on it? Is it as large as the one I showed you? Is it larger or smaller or the same size? Can you run your finger around the edge and show me how big it is? Is it still there or is it gone?

The last question was asked frequently and was, in practice, interpolated repeatedly between the other questions The child's expression and attitude were closely watched to note whether he really appeared to be looking at something externally projected

If the child failed to experience an after-image, the examiner demonstrated the technique of fixation, saying,

> If you look hard enough, you'll still see the picture after I take it away. You have to look right at it all the time I'm showing it to you See how I do I look right at the dot in the middle

Before the second after-image stimulus was presented, the examiner said,

> Now I am going to show you the picture of a bear, a big black bear If you look at it hard, you can still see it after I take it away It may not be black, it may be some other color, but you will see it right there. Look at it hard, and don't look at anything else Look right at the bear's eye (*The stimulus picture was removed*) Can you see anything now? What do you see? What color is it? Where is his nose? Where is his tail? (*The latter two questions helped in determining the size.*) Is it still there, or is it gone?

Short rest periods were given between pictures Before beginning the testing for the eidetic imagery, the examiner explained to the child,

> There will be lots of things to see in the next picture Look at all the things in it Look around at everything in the picture (*After the stimulus picture was removed, the examiner asked*), Do you see anything? What do you see? (*Other questions were asked as the child's answers suggested, for example*), What does the little boy have in his other hand? What is the bird doing? What else do you see? Do you still see something, or is it gone?

If the subject did not report an image immediately after the removal of the stimulus-picture, he was told, "Keep looking You might see something in a moment." Some individuals do not experience an image immediately after the removal of the stimulus The short time between the removal of the stimulus and the appearance of the image may be termed a "latent period"

Records

The time-keeper recorded everything the subject said on a record blank, as well as the duration of the image in seconds, the size of the image, and colors The individual record blank used was one worked out by Miss Rosemary Walling This blank was designed for the purpose of uniformity in recording, and greatly facilitated tabulating the results.

There is a separate space on the record blank for recording the time, divided into time for (*a*) the total duration of the image, (b) the latent period, if any, between the exposure of the stimulus and the appearance of the image, and (*c*) the period of time during which the image appeared and disappeared, in the case of an intermittent image. The duration of an image was the time elapsing between the subject's first report of an image and his report of its disappearance. A few subjects having images after a latent period were found in each racial group. Such cases were recorded by timing the subject from the time the stimulus-picture was removed until he experienced an image, and then again until the image disappeared. Only one strong case of an intermittent image was found. One little negro girl would exclaim, "Now the rabbit is here. Now it's gone." (*After a second or two.*) "There it is again." In cases of intermittent images, the total number of seconds were recorded. For example, if the child's first image lasted 15 seconds, the reappearance lasted 12 seconds, and the third reappearance lasted 10 seconds, the time-keeper would record 37 seconds beside the space marked intermittent on the record blank.

The subject was credited with having an eidetic image only if details could be pointed out. Whenever a subject reported, "I see a red line" or "I see some black spots," for example, these were not counted as images. In tabulating the number of details from the record blanks, the investigators counted as details (*a*) objects, (*b*) colors, (*c*) relationships, (*d*) action, and (*e*) descriptive words and phrases.

RESULTS

After-Images. Table 1 gives a summary of the data concerning

TABLE 1

SUMMARY OF DATA CONCERNING AFTER-IMAGES

Group	Number of after-images	Duration (Seconds)		Initial coloring (Percentage of images)			
		Range	Average for A I	Positive	Negative	Achromatic	Other colors
White (208)	337	5-430	38.3± 7.15	34	38	11	17
Mexican (50)	95	5-150	44.1± 5.64	50	38	6	6
Negro (50)	99	5-360	84.9±11.85	58.5	32.3	5.1	4.1

the total duration and coloring of the after-images of the three racial groups. The average duration is much higher among the Negro subjects than among the other two groups. The white subjects have the lowest average duration. The data as to the coloring of the images is affected by the possibility that many of the three- and four-year-old subjects did not know the names of the colors. In many cases the investigator named the colors with the children before beginning the testing The highest percentage of positive coloring is found among the Negro children The Mexican subjects rank next as to positive coloring The white subjects have a higher percentage of negative after-images than positive ones, but a much higher percentage of other colors are reported by them than are reported by either of the other two groups. If, as Jaensch (10) suggests, young children tend toward the "unitary type" with eidetic images and after-images closely related to each other, then these results indicate that between 50 and 60 per cent of the after-images in each of these three racial groups were not true after-images but really eidetic images

EIDETIC IMAGES

Figure 1 shows the percentage of eidetikers among white, Mexican and Negro subjects at the various age levels The highest percentage of eidetikers is found at the four-year age level among the white and Mexican subjects Among the Negro subjects the highest percentage of eidetikers is found at the five-year age level In each racial group the percentage of eidetikers at the three-year age level is nearly the same as that at the six-year age level, this percentage is exactly the same with the Negro subjects Fifty-four per cent of the Mexican, 84 per cent of the Negro, and 50 9 per cent of the white subjects reported eidetic images.

Table 2 is a summary of the duration, number of details, and coloring of the eidetic images among the three racial groups The Negro eidetikers lead both in average duration and average number of details The Mexican subjects are next as to the average duration, but the white subjects lead them in the average number of details reported The coloring of the eidetic images almost runs parallel to the coloring of the after-images in each of the three groups. The Mexican subjects lead in percentage of positive coloring with 84 per cent The Negro subjects have the highest percentage of negative coloring A low 33 per cent of positive coloring among the white subjects is balanced somewhat by the high percentage of other colors, achromatic, and mixed colors In those cases where no colors are reported the subjects possibly saw a color but would not report it, or in their eagerness to describe details failed to mention color

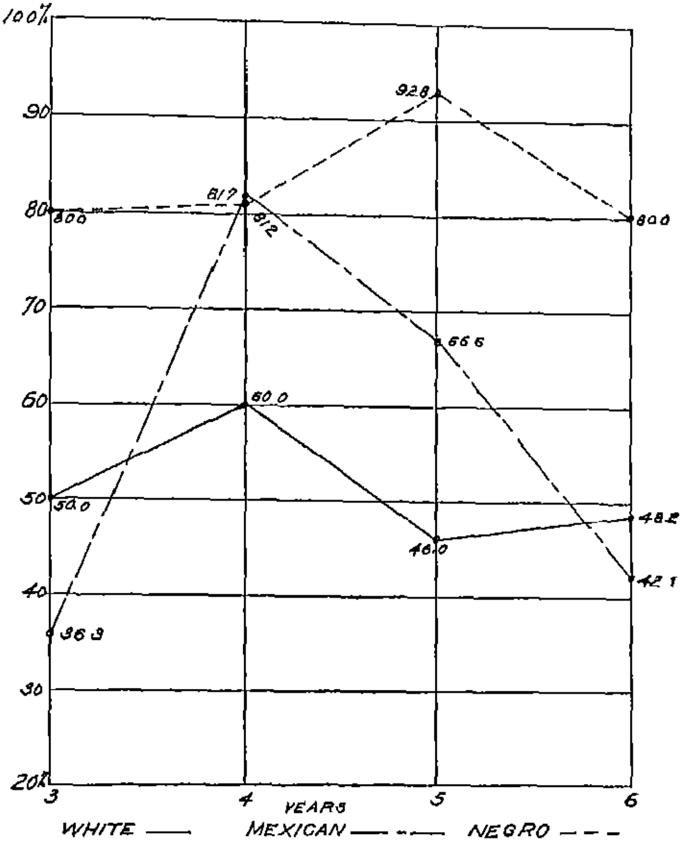

FIGURE 1

COMPARISON OF THE PERCENTAGE OF WHITE, NEGRO, AND MEXICAN EIDETIKERS AT DIFFERENT AGE LEVELS

Table 3 is a comparison of the quality of eidetic images among Mexican, Negro, and white children at different age levels. This table gives the average duration, and the average number of details of the combined eidetic images at the different age levels. The sum of the average durations for each of the three stimulus pictures, divided by three, shows *the average time of one eidetic image.* When average duration is used as a criterion for determining the strength

TABLE 2

SUMMARY OF DATA CONCERNING EIDETIC IMAGES

Group	Number of eidetic images	Range	(Secs) Average for one E I	Range	Number of details Average for one E I	Pos.	Neg	Achro.	Other Colors	Mixed	No Color
White	236	3-1104	73 8±5 79	1-64	8 2± 43	33	3	1	13	8	42
Mexican	*75*	*10-350*	*92 3±6 89*	*2-15*	*6 8± 41*	*84*	*2*	*0*	*7*	*7*	*0*
Negro	116	10-300	115 3±5 75	1-27	10 5± 48	82	5	0	6	7	0

TABLE 3

Comparison of the Quality of Eidetic Images Among White, Mexican, and Negro Children at Different Age Levels

A. Average duration for one eidetic image

Age	White	Mexican	Negro
6 yrs	80.7	113.7	120.3
5 yrs.	78.7	89.2	133.9
4 yrs	64.3	82.2	101.6
3 yrs.	67.3	80.2	95.2

B. Average number of details for one eidetic image

Age	White	Mexican	Negro
6 yrs	9.7	8	15.6
5 yrs	9.6	7.1	9.5
4 yrs	7.7	4.7	9
3 yrs	5.2	4.5	7.9

of eidetic ability, the lowest averages are at the three-year age levels for the Mexican and Negro subjects, and at the four-year level for the white subjects. The highest average duration is found at the five-year level for the Negro subjects, and at the six-year level for the white and Mexican subjects.

The Negro subjects lead in the average number of details at every age level except at the five-year level, and at that level they have almost the same averages as the white subjects. The highest number of details is found at the six-year age level with all groups. The lowest average number of details is found at the three-year level with all groups. This low average at the three-year level is probably due to the small vocabulary of the three-year-old child.

Table 4 is a comparison of the white, Mexican, and Negro subjects with regard to incidence and quality of after-images and eidetic images. The Negro and Mexican groups are higher in percentage of after-images and eidetic images reported than are the group of white subjects. The Negro subjects have a much higher percentage of eidetic ability than the other groups. Both Negro and Mexican subjects report a higher average number of positively colored after-images and eidetic images than do the white subjects.

Individual Differences

Subject 8 among the six-year-old white subjects is an outstanding eidetiker. This subject's total duration for the three eidetic images was 2,471 seconds or nearly 42 minutes. The image of longest

TABLE 4

Comparison of White Mexican, and Negro Subjects

A. After-images

Group	Number	Number reporting after-images	Average age (months)	Percentage reporting after-images	Av dur for one after-image (seconds)	Coloring (Percentage of images) Posi-tive	Nega-tive	Achro-matic	Other colors
White	208	187	54	89.9	38.3± 7.15	54	38	11	17
Mexican	50	49	56	98	44.1± 5.64	50	38	6	6
Negro	50	50	52	100	84.9±11.85	58.5	32.3	5.1	4.1

B. Eidetic images

Group	Number	Number reporting after-images	Average age (months)	Percentage reporting eidetic-images	Av dur for one eidetic image (seconds)	Coloring (Percentage of images) Posi-tive	Nega-tive	Achro-matic	Other colors	Mixed	No colors reported
White	208	106	54	50.9	73.8±5.79	53	3	1	13	8	42
Mexican	50	27	56	54	92.3±6.89	84	2	0	7	7	0
Negro	50	42	52	84	115.3±5.75	82	5	0	6	7	0

duration was secured from the second stimulus picture, which was *a silhouette in colors of a circus scene* The total duration for this image was 1,104 seconds with 64 accurate details reported.

Subject 31, a four-year-old Mexican child is an outstanding eidetiker in that group, but he does not approach Subject 8 of the white group either in duration or in number of details This subject also had an eidetic image of longer duration from the second stimulus picture than from the other two pictures This second image lasted 350 seconds His first image lasted 237 seconds with 14 accurate details reported, compared to 13 details reported in the second image.

Subject 42 among the Negro subjects is one of the strongest eidetikers in any of the racial groups at the three-year age level. His first two images lasted 240 seconds, and 260 seconds, respectively. He reported 22 accurate details from the first image and 27 from the second image His third eidetic image lasted only 120 seconds with 10 accurate details reported. Possibly he became fatigued during the last image

AGE DIFFERENCES

The low average of number of details reported in all of the groups at the three-year age level is probably due to the inattentiveness of the three-year-old child The attention span at that age level is considerably shorter than with older preschool children The three-year-old child's vocabulary is somewhat limited also. Greater richness of detail of the images at the six-year level in all three races is probably due to the six-year-old child's having a somewhat larger vocabulary than the children at lower age levels There is not so great a proportional difference as to average duration of images among the six-year-old subjects. There is a tendency for average duration to lengthen with each succeeding age, beginning with the three-year level, with an exception in the case of the four-year-old white subjects

RACIAL DIFFERENCES

The Mexican subjects had a lower average of details at every age level than the other two groups There is a possibility that a language difficulty was encountered in the testing situation Although the investigator and the recorder talked to the non-English speaking children in Spanish, they seemed reserved about replying in their native tongue. Many times they were observed to stare at the projection screen, and when asked what they saw, their only reply would be, "It's gone."

The Negro subjects not only had more eidetic images than the other two groups, but they also led in average duration at every age level They led again in the average number of details reported at every age level except at the five-year level where they reported nearly the same number of details as the white subjects.

There was a decided difference in the reactions to the testing situation among the three races. The Negro subjects were able to fixate for the after-images and concentrate for the eidetic images better than the other groups at all age levels The Mexican subjects were somewhat nervous and ill at ease. This last statement was particularly true of the younger subjects. The white subject's attitude toward the testing situation might be described as highly expectant. On the whole, all of the subjects were very cooperative, and their responses showed that the technique was one which fitted the understanding and interest of preschool children.

As determined by the critical ratio of the sigma differences, there is no reliable difference between the average duration of an after-image among the white children and that among the Mexican children (Table 5) There is no reliable difference in the average duration of an after-image between the whites and Negroes, nor between the Mexicans and Negroes.

There is no reliable difference between the whites and the Mexicans nor between the Negroes and the Mexicans concerning the average duration of an eidetic image (Table 5) The critical ratio of the sigma differences between the white and the Negro children in the average duration of an eidetic image is 5.08, showing the difference between those groups to be a highly reliable one

As regards the average number of details reported for an eidetic image, the difference between the whites and the Mexicans is not entirely reliable, there are 989 chances in 1000 that the whites exceed the Mexicans. There is a reliable difference between the whites and the Negroes with a critical ratio of 3 59. The critical ratio of the sigma differences between the Mexicans and the Negroes is 5.87. The indications are that the Negroes would always lead the other two groups, both in duration of eidetic images and in number of details

TABLE 5

RELIABILITY OF DIFFERENCES BETWEEN THE VARIOUS GROUPS

Groups	Type of imagery	Criterion of imagery	Group excelling	S D of Diff	Critical ratio	Chances in 1,000 that *Diff* is a true Diff.
White-Mexican	After-image	Duration	Mexican	9.10	.637	730
Mexican-Negro	After-image	Duration	Negro	41.5	983	830
White-Negro	After-image	Duration	Negro	43.7	1.06	850
White-Mexican	Eidetic image	Duration	Mexican	8.99	2.06	890
Mexican-Negro	Eidetic image	Duration	Negro	8.97	2.56	994
White-Negro	Eidetic image	Duration	Negro	8.16	5.08	999
White-Mexican	Eidetic image	Details	White	594	2.37	989
Mexican-Negro	Eidetic image	Details	Negro	631	5.87	999
White-Negro	Eidetic image	Details	Negro	644	3.59	999

SUMMARY AND CONCLUSIONS

The present study is an investigation of the incidence and quality of visual eidetic images among white, Negro, and Mexican preschool subjects The purpose of this study was to compare these three racial groups as to incidence and quality of visual eidetic images, thereby determining the existence or non-existence of racial differences in eidetic ability The need for the present study was apparent as no study had been made of racial differences with preschool children

Two hundred eight white children, 50 Negro children, and 50 Mexican children were examined for after-images and visual eidetic images The technique used had been adapted to examining preschool children in a preliminary study by Peck and Walling.

Two tests were given for after-images, and three stimulus silhouette pictures were used in testing for eidetic images Eighty-six per cent of the white children, 92 per cent of the Mexican children, and 100 per cent of the Negro subjects reported after-images Positive after-images predominated among the Mexican and Negro groups Negative images were slightly more frequent than positive ones among the white children, but the children reported a higher percentage of achromatic and other colors than the other two groups.

Fifty-four per cent of the Mexican subjects, 84 per cent of the Negro subjects, and 50 9 per cent of the white subjects reported eidetic images The percentage for the white children agreed with the findings of Peck and Walling in their preliminary study using 20 preschool subjects (23). Considerable age differences in eidetic ability were found. The highest percentage of eidetikers among the Mexican children was found among the four-year-olds, 81 7 per cent of whom were eidetic. The incidence of eidetic ability was also highest at the four-year level for the white subjects, with 60 per cent at that level reporting eidetic images In the case of the Negro subjects, the highest eidetic ability was found at the five-year level, with 92.8 per cent reporting eidetic images In all three racial groups the percentage of eidetikers at the three-year age level was approximately the same as that found at the six-year level

The three racial groups were compared as to quality of eidetic images The majority of eidetic images were positive in the Mexican and Negro groups There were more negative than positive images among the white subjects, but that group had more other colors, achromatic, and mixed colors than the other two groups.

The Negro subjects ranked highest as to duration of images at all age levels. They ranked highest as to the average number of details at every age level except at the five-year level where they had nearly the same average as the white subjects. The white subjects ranked next to the Negro group in average number of details at every age level except the five-year level where they slightly exceeded them. The Mexican subjects ranked next to the Negro group in duration of images at every age level.

The results indicate the existence of racial differences in eidetic ability of preschool children. The fact that the Negro group not only led in percentage of eidetic images, but also led the other groups in richness of detail and duration of images, indicates that they possess a higher eidetic ability than the white and Mexican children. The findings of this study indicate that the Mexican children possess a slightly higher eidetic ability than the white children. Whether Negro children above the preschool age level would lead the other two races in eidetic ability is an interesting study for future investigation.

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EXPERIMENTS IN REPETITION AND RECALL*

Medical College of New York University, and Bellevue Hospital

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Part I

We have studied the problem of memory by what we think is a new method We read a short story to our subjects and ordered them to repeat the story again and again until they were exhausted and refused to continue

This technique was suggested by the experiments of Anitra Karsten on psychic saturation, such experiments having been previously suggested by Lewin A similar technique has been used by Hoppe on suckling babies and by Freund in menstruating women Karsten directed her subjects to draw fence pickets on sheets of paper until they lost all desire to continue the work The qualitative analysis revealed the following features

> At the beginning, the side of a page constitutes a unit of effort Later a dissolution of the original configuration occurs, variability in performance being prominent in the final stages Concurrently, errors and loss in quality appear and eventually the task loses its meaning. The work not only becomes disorderly and loosely connected, devoid of definite boundaries and termini, but breaks up into little independent fragments A larger whole has disintegrated.

Although Karsten has also used more complicated patterns, the task demanded from the individual remains simple Furthermore no problem of memory was involved, since the individuals had a pattern before them and the pattern was so simple that it was not liable to be forgotten Our own experiments deal less with the problem of exhaustion than with the problem of retention and recall We were interested to learn which parts of a story would appear when repeated recall is demanded after one exposition

After various stories had been tried out, we used for the main part of our investigations the following story

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> Olaf Nelson-died here-to-day-of burns suffered-when a match ignited-his grass skirt-in a hula dance comedy-during the American Legion-convention -District Attorney-Brown-announced-that he would file-manslaughter charges-against Mr Moore -Moore-lighted-a cigarette-and tossed away the match.-Brown interviewed-fifteen witnesses-who said Moore-deliberately tossed-the match to Nelson's costume

This story which, as the hyphens indicate, consists of twenty-four items was read slowly and aloud to the subject once. The subject was instructed to listen carefully and to repeat the story as often as he could He was told "We want to see how often you can repeat the story before getting exhausted" We used 21 subjects. They were either medical students or student nurses or patients who had come to the hospital in the state of acute excitement or intoxication but who were normal at the time when the test was taken One case of organic memory disturbance, one Korsakoff case, and one Schizophrenic case were used for comparison We did not study merely the results from a qualitative point of view but we checked, in every repetition, whether each of the 24 items were (*a*) correct, (*b*) changed, (*c*) absent or (*d*) whether other items were added After we had finished the qualitative survey we were able to use a more elaborate scheme for tabulation which has been applied for the working through of seven protocols In two of the normal cases and in the Korsakoff case both methods were applied The following scheme was used·

I Number of words of the story
  a In the original story
  b. In last repetition
  c. In present report
II. Number of added words
  a. To original story
  b To last repetition
III Number of omitted words
  a From original story
  b From last repetition
IV. Phrase substituted by similar phrase
V. Phrase added to story
VI Added phrase expressing merely attitude of subject
  a Impatience

b Disgust, uncertainty
c Jokes
d Rebellion.
e Gabby or talkative attitude.
VII Substitution of word which is a synonym (*A*) or is similar (*B*)
VIII Substitution of a word which has a more general meaning
IX Substitution by a more specific word.
X Substitution by a more common word
XI Substitution by a less common word
XII Perseveration
XIII Emotionally stronger
XIV Emotionally lighter
XV Deprecation
XVI Colloquialism (vulgarity)
XVII By a more moral word
XVIII Substitution by a less moral word
XIX *Newly added words which do not substitute other words*
a Change in individual names
XX Items omitted
XXI *Perseveration of mistakes*
a In individual names
XXII *Correction of mistakes*
a In individual names
XXIII *Reappearance of omitted words.*
XXIV Reappearance of omitted sentences
XXV *Changes in the place (location) of a word ante-position (A)*, post-position (*B*)
XXVI Reversal between two items

When a change fell into two categories, the more important one was tabulated. The title of the story was read to the subject but no reproduction of this was asked.

We proceed in reproducing one of our protocols taken from a healthy young 20-year-old woman, Eve Sch.

> *First trial* Olaf Nelson died today because of serious injuries he received when his costume was set afire It was during a hula dance comedy given by some convention that a Mr Moore lighted a cigarette, and threw the match away The D A interviewed about 15 people who said that Mr. Moore purposely

threw the match at Mr Olaf's grass skirt, Mr Nelson's grass skirt The D A is bringing some charge against him

Second trial A Mr. Olaf Nelson died last night from serious injuries which he received when his grass skirt caught afire at a hula dance comedy given by some big convention The D.A questioned the guests and about 15 of them said that a Mr Moore had deliberately thrown a match at Mr Nelson's grass skirt after Mr Moore had lighted a cigarette Charges are to be brought against Mr Moore

Third trial A Mr Olaf Nelson died last night from serious injuries (pause) after (pause) his grass skirt which he was wearing caught afire (I know the story, but I just don't feel good that's why I'm hesitating I've served six days here and I want to go home. I came here voluntarily.) The D A. interviewed the guests and 15 of them said that a Mr Moore deliberately threw a match at Mr Nelson's grass skirt This all took place at a hula dance comedy given by some convention Charges are to be brought against Mr Moore

Fourth trial A Mr Olaf Nelson died from serious injuries received when the grass skirt which he was wearing caught afire The D A. interviewed the guests and 15 of them gave the same story They said that a Mr Moore, who had thrown the match, after lighting a cigarette had thrown it purposely at Mr Nelson's grass skirt This all took place at a party, at a hula dance comedy given by a convention So charges are to be brought against Mr Moore. (Speaks slowly with long pauses)

Fifth trial Again? A big Swede (jocularly)—a Mr Olaf Nelson—died last night from serious injuries received when his grass skirt which he was wearing, caught afire. Fifteen of the guests told the D A that a Mr Moore deliberately threw a match at Mr Nelson's grass skirt Charges are to be made against Mr. Moore This all occurred at a hula dance comedy given by some convention That's all

Sixth trial A Mr Olaf Nelson died last night from serious injuries which he received when his grass skirt which he was wearing caught afire The D A questioned the guests and 14 of them said that a Mr Moore threw the match deliberately at Mr Nelson's grass skirt Charges are to be made against Mr Moore This all occurred-the accident occurred-because it might have been an accident-at a hula dance-comedy given by some convention That's all

Seventh trial A Mr Olaf Nelson died last from serious injuries received when the costume which he was wearing caught afire The guests told the D A that a Mr Moore *deliberately threw a match at Mr. Olaf's* grass skirt Charges are to be made against Mr Moore The accident occurred during a hula-comedy given by some convention

Eighth trial. Enjoy yourself I don't care. Write from now to doomsday I'm getting a little bit nuts from this Maybe they're trying to make a mental case of me even though I'm not one But I'm getting a kick out of it just as much as they are—A Jew named Freedman is a darned pest always giving me tests (good humoredly) A man-a Mr Olaf Nelson died last night from injuries received when the costume he was wearing—15 of the guests told the D A that a Mr. Moore deliberately threw a match at Mr Nelson's costume The charges are being brought up against Mr Moore This—the *accident occurred in the midst of a hula dance comedy given* by some convention That's all Satisfied-yet?

Ninth trial. A Mr Olaf Nelson died recently from severe *burns after his costume caught afire by a match thrown carelessly* in his direction The guests told the D.A that a Mr. Moore threw the match purposely towards Mr—Mr Nelson's *costume. Serious charges are being served to Mr Moore* The accident occurred while a hula dance comedy was going on at some convention That's all

Tenth trial A Mr Olaf Nelson died last night from serious *injuries received when his costume caught afire* The guests told the D A that a Mr Moore threw a match purposely at Mr Nelson's costume Serious charges are being brought up *against Mr Moore This all occurred at a hula dance comedy* given by some convention.

Eleventh trial (She goes to window) A Mr Olaf Nelson died recently from serious burns which he received when his costume caught afire The guests told the D A. that a Mr Moore threw the match purposely at Mr Nelson's costume Serious charges are being made against Mr Moore The accident occurred during a hula dance comedy given by some convention. 'S all

Twelfth trial A Mr Olaf Nelson died recently from serious burns which he received when his *costume caught afire* The guests told the D A that a Mr Moore purposely threw a match at Mr Nelson's costume Serious charges are being made against Mr Moore The accident occurred during a hula dance given by some convention

> *Thirteenth trial.* The next day the patient repeated in the following way—Mr. Olaf Nelson died. I will draw you a picture instead. (Patient draws now the head of a woman and refused to go on with the Nelson story.)

The qualitative analysis can be summarized as follows:

First trial. Patient uses "set afire" for "ignited." Forgets what convention was mentioned. Repeats "about fifteen" and calls them "people" instead of "witnesses." Says that match was "thrown at" skirt instead of "touched to" it, and refers to the victim as "Mr. Olaf" (first name) instead of "Mr. Nelson." Cannot remember specific charges being filed. Uses "charge" (singular) instead of plural and speaks of them as being "brought" instead of "filed." Says "serious injuries" for "burns" and "purposely" for "deliberately."

Second trial: Calls Nelson "A Mr. —." Says died "last night" instead of "today." Correctly uses "deliberately" instead of "purposely." Calls witnesses "guests." Remembers to bring in the cigarette. Otherwise repeats previous mistakes. Changes previous "set afire" to "caught afire."

Third trial: Marked delays and resistance. Brings in "which he was wearing." Corrects "about fifteen" to "fifteen." Died "last night" instead of today (perseveration). Forgets to mention cigarette. Still says "guests" for "witnesses." Repeats "caught afire."

Fourth trial. Reverts to "purposely." Elaborates: "interviewed the guests and 15 of them gave the same story." Sentence structure becomes involved. Lapses: "This all took place at a party" and then corrects herself saying, "at a hula dance comedy." Colloquialism: "So"— Omits time of death entirely.

Fifth trial: Starts jocularly, "A big Swede, a Mr. Olaf Nelson." Perseveration: "Fifteen of the guests instead of "fifteen guests" (as previously) or "fifteen witnesses" (correct version). Omits cigarette. Closes with "That's all."

Sixth trial. Corrects self on inconsequential point, changing "caused by" to "which he received when—." D.A. "questioned" instead of "interviewed." Superego scrupulosity—"This all occurred-the accident occurred-because it might have been an accident—."

Seventh trial: Perseverations: "guests", "deliberately"; "accident" and "serious injuries" Refers to "Mr Olaf's" instead of "Mr Olaf Nelson's grass skirt."

Eighth trial Patient starts with a good many good humored observations of a subjective nature, including reference to the tester "A man-a Mr Olaf Nelson." Forgets to finish sentence with verb for catching fire Variation. "The charges are being brought up against Mr Moore." "This-the accident occurred " Ends with "Satisfied yet " "Injuries" used without "serious"

Ninth trial Uses "died recently" for "died last night" (correct form "died today"). Variation "by a match thrown carelessly in his direction" "The guests told D A. a Mr. Moore threw the match purposely towards Mr —Mr Nelson's costume" "Serious charges are being" served to "Mr M." "The accident " Number of "guests" is omitted "Severe burns" for "burns"

Tenth trial. "Recently" is changed back to "last night" Number of "guests" is omitted. "This all occurred during . " Terse. "Serious injuries" replaces "severe burns" again

Eleventh trial She goes to window "Recently" for "last night." "Serious burns" replaces "serious injuries" " . a Mr Moore." "Serious charges are being made. . . ." "The accident occurred " Ends with " 'S all." Number of "guests" omitted. Terse.

Twelfth trial: "Serious burns" repeated Number of "guests" omitted Terse. Last three versions are almost identical.

Thirteenth trial "Mr Olaf Nelson died—I'll draw you a picture instead" (Draws a profile of a girl with curls resting on shoulder) "Is that Mr. Nelson?"

The repetition on the next day shows merely the enormous resistance which has developed in the patient and persists up to the next day

We have tabulated the results with our two methods, which we illustrate in the two adjoining tables (Tables 1 and 2)

EXPLANATION OF THE TABLE

The left column contains the comparison with the original story. The right column contains the comparison with the preceding repetition The Roman numerals indicate the items

I Number of items correctly repeated

II Number of items changed.

TABLE 1
E S

	I	II	III	IV	I	II	III	IV
1	6	14	4	2				
2	5	15	4	1	6	12	3	1
3	5	13	6	8	14	4	2	7
4	4	16	4	3	15	6	6	2
5	6	11	7	6	12	6	3	4
6	5	14	5	5	14	3	2	3
7	4	13	7	3	13	7	4	0
8	3	13	8	8+13	13	6	1	5+13
9	2	14	8	5	11	10	13+4	4
10	4	12	8	2	14	6	3	0
11	5	11	8	3	13	5	0	1
12	4	12	8	1	17	1	1	0

III Number of items omitted
IV Number of items added
The Arabic numerals indicate the number of the trial.

EXPLANATION OF TABLE 2

The left column contains the comparison with the original story The second column contains the comparison with the preceding repetition The number in the left corner indicates the number of the trial The vertical column of numbers point to the respective number of the complete scheme. The number of (x) signs indicates the approximate frequency of the change indicated by the number.

A look at these tables confirms immediately our qualitative results and gives them a more definite shape. The table concerning the items shows that material which was not available for one repetition may be available for the next repetition. The comparison of items correctly reproduced in the different repetitions shows that continuous changes take place It is moreover of interest that only in the first seven repetitions the number of omitted items shows changes and that after the eighth repetition the number of omitted items remains constant It is also noteworthy that after an emotional outburst at the eighth repetition the number of additions decreases steadily. It is furthermore interesting as indicated by the column on the right side that the subject has in general the tendency to cling to her version of the story and, of the 19 items produced in the 11th

TABLE 2

E. S.

1

1a = 66
1c = 64
2 = 34
3 = 36
4 xxx
9 x
10 xxxx
12 x
20 xx
26 xx

2

1a = 66
1b = 64
1c = 64
2 = 34
3 = 36
4 xx
9 x
10 xx
19 xxx
23 x
25b x

1b = 64
1c = 64
2 = 18
3 = 18
4 xx
10 x
19 xxx
20 x
23 xx
25a xx

3

1a = 66
1b = 64
1c = 94
2 = 74
3 = 46
4 xx
6c x
9 x
10 x
19 xxxx
20 x
25b x

1b = 64
1c = 94
2 = 34
3 = 4
6e x
19 xxxxx
23 x

4

1a = 66
1b = 94
1c = 72
2 = 56
3 = 50
4 x
9 x
10 xxx
19 xxxxxx
20 x
25b xx

1b = 94
1c = 72
2 = 26
3 = 48
4 x
19 xxxxx
10 x
20 x

5

1a = 66
1b = 72
1c = 64
2 = 40
3 = 42
4 xx
6a x
6c x
9 x
10 xx
19 xxxxxxx
20 x
25b x

1b = 72
1c = 64
2 = 20
3 = 28
4 x
6a x
6c x
19 xxx
20 xx

6

1a = 66
1b = 64
1c = 70
2 = 46
3 = 42
4 xx
9 x
10 xx
19 xxxxxxxxxx
20 x
23 x
25b x

1b = 64
1c = 70
2 = 30
3 = 24
19 xxx

7

1a = 66
1b = 70
1c = 60
2 = 38
3 = 44
4 x
9 x
10 xx
19 xxxxxx
20 x
23 x
25b x

1b = 70
1c = 60
2 = 20
3 = 30
10 x
4 x
20 xx
25a x

8

1a = 66
1b = 60
1c = 142
2 = 90
3 = 44
4 x
6d xxxx
6e x
10 x
19 xxxxxxxxxxx
xxxxxx
20 xx
23 x
25b x

1b = 60
1c = 112
2 = 90
3 = 44
4 x
6d xxxxx
6e x
19 xxxxxx
20 xx

9

1a = 66
1b = 112
1c = 63
2 = 40
3 = 43
4 x
9 x
10 xxx
12 x
19 xxxxxxxx
20 x
25b x

10

1a = 66
1b = 63
1c = 60
2 = 41
3 = 47
4 x
9 x
10 xx
12 xx
19 xxxxxx
20 x
25b x

1b = 63
1c = 60
2 = 12
3 = 15
4 xxx
20 xx
23 x

11

1a = 66
1b = 60
1c = 56
2 = 30
3 = 40
4 x
9 x
10 xx
12 xx
19 xxxxxx
20 x
23 x
25b x

1b = 60
1c = 56
2 = 9
3 = 13
4 xxx
19 x
23 x

12

1a = 66
1b = 56
1c = 55
2 = 30
3 = 41
4 x
9 x
10 xxx
12 xxx
19 xxxx
20 x
25b x

1b = 56
1c = 55
2 = 6
3 = 7
20 x
25a x

repetition, 17 are correctly repeated in the 12th repetition, only one is omitted One comes to the conclusion that a rather active process of continuous change and testing comes to a relative rest and a stabilized pattern occurs after the eighth repetition The table based upon the complete scheme shows, for instance, that the number of words omitted from the original story increases at the third repetition, but remains almost constant after the fourth repetition. At the 12th repetition the number of omitted words is only 41 whereas the number of omitted words in the 10th repetition was 47. The number of added words goes up with the emotional outburst with the eighth repetition but decreases also considerably towards the end of the experiment The right columns show the same characteristics even more clearly; in the last repetition, for instance, only six new words are added and seven words of the previous repetition are omitted Of the other items of the general scheme nine and ten are particularly interesting Substitutions of words by words which are more specified are infrequent in comparison with the substitution of words for words which are more common Perseveration is encountered much more often towards the end of the series. Changes in the location of words are common Words which have been omitted may reappear at any time.

A second protocol may confirm us in the opinion that we do not deal merely with chance results in the first protocol discussed

Rose W., a normal subject, age 27, shows the following results

(1) Olaf died here to-day while doing a hula dance from a match touched his skirt The D A. something—

(2) Olaf died here to day while doing a magic dance, from a match that touched his skirt. The D A said he has witness

(3) Olaf died here to-day while doing a magic dance, from a match that touched his skirt. The D.A says he has witnesses for something

(4) Worlof died here to day while doing a magic dance from a match that touched his skirt while dancing for some kind of society or something

(5) Some District Attorney or something Worlof died here to-day while dancing a magic dance from a match that touched his grass skirt

(6) Worlof or Orlaf died here to-day while doing a magic dance from a match that touched his grass skirt Some kind of D A, or something

(7) Gracious—Orlof, whoever he is, he died here to-day—no—yes—while doing a magic dance—no—yes—a match touched his grass skirt From a burn—I didn't say that before He was at a charity ball The D A. said something about witnesses Twelve witnesses

(8) Orlof died here to-day from a burn while doing a magic dance from a match that touched his grass skirt That's as far as I can go I can't get in that about the D A and the 12 witnesses I'm usually good at remembering things. (Patient interrupts continually to tell about troubles)

(9) I have to laugh Orlof died here to-day while doing a magic hula-hula dance from a match that touched his grass skirt Now, that's as far as I can go,—D A. and 12 witnesses—charity organization.

(10) Orlof died here to-day from a burn while doing a magic hula-hula dance from a match which touched his grass skirt The D A says that he has 12 witnesses as far as I can remember

(11) (Sulks) Orlof died here to-day while doing a magic hula-hula dance The D A says he has 12 witnesses.

(12) Orlof says—Worlof died here to-day while doing a magic hula-hula dance The witness says he has 12 witnesses (Subject weeps)

On the following day, without repetition of the original story, she says "Orlof died here today while doing a magic hula dance from a burn which touched from a match which touched his grass skirt. And the D A says he has 12 witnesses that saw him burned."

TABLE 3
R. W

	I	II	III	IV	I	II	III.	IV.
1	2	5	17	2				
2	2	7	15	1	8	1	0	3
3.	2	7	15	3	9	1	0	1
4	2	4	18	5	6	1	4	4
5	3	5	16	3	6	1	3	3
6	3	6	15	4	8	1	0	2
7.	3	8	13	10	7	1	2	11
8	3	6	15	5	9	1	8	3
9	4	4	16	5	9	2	3	3
10	3	8	13	3	7	3	2	2
11	2	6	16	0	7	0	4	0
12	2	4	18	4	6	0	2	1
		NEXT DAY			WITHOUT REPETITION			
13	3	8	13	6	7	2	1	6

TABLE 4
R W.

1
1a = 66
1c = 19
2a = 4
3 = 51
4 x
10 x
18 x
20 xxxxxxx

2
1b = 19
1c = 24
2a = 4
3 = 49
4 x
8 x
10 x
20 xxxxxxxx
23 x
24 x
2 = 6
3 = 1
8 x
19 x

3
1b = 24
1c = 27
2 = 7
3a = 49
4 x
8 x
10 x
19 xxxxx
20 xxxxx
2 = 3
3 = 0
21 xxx

4
1b = 27
1c = 26
2a = 14
3 = 53
4 xx
10 x
18 x
19 x
20 xxxxxx
24 x

5
1b = 26
1c = 23
2 = 11
3 = 54
4 xx
8 x
15 x
19 x
20 xxxxxx
2 = 5
3 = 7
15 x
21 xxx
24 x

6
1b = 23
1c = 27
2 = 15
3 = 54
4 xx
8 x
15 x
19 x
20 xxxxxx
2 = 7
3 = 0
10 x
15 x
19 xx
21 x
26 xx

7
1b = 27
1c = 49
2a = 32
3 = 49
4 x
5 x
6a x
10 x
15 x
19a x
21a x
2 = 28
3 = 5
6a x
6b x
6c x
10 x
15 x
21a x

8
1b = 49
1c = 46
2 = 30
3 = 53
6a xx
8 x
20 xxxxxx
2 = 22
3 = 20
6 xx
21 x
21a x
20 xx

9
1b = 46
1c = 37
2 = 16
3 = 53
6a = xx
7 x
19a x
20 xxxxxx
23 x
2 = 6
3 = 13
6ac x
7 x
21 xx
23 x

10
1b = 37
1c = 29
2a = 7
3 = 59
7 x
19a x
20 xxxxxxx
2 = 2
3 = 9
6 x
20 x
21 xxxxxx

11
1b = 34
1c = 20
2a = 3
3 = 60
7 x
10 x
19c x
20 xxxxxxx
2b = 0
3 = 14
21 xxxx
20 x

12
1b = 20
1c = 21
2 = 4
3 = 55
17a x
19a x
20 xxxxxx
25 x
2 = 1
3 = 2
20 x
21 xxxxxx
25 xx

13 (NEXT DAY)
1b = 21
1c = 36
2 = 20
3 = 51
4 xxx
7 x
19 xx
19a x
20 xxxxx
3 = 20
21a x
23 xxx
24 xxxx

We may omit the qualitative analysis and proceed immediately with the discussion of the tables (3 and 4) It is characteristic that whereas in the first four repetitions only two items are correct, the number of correct items from the fifth to the eighth repetition is three and that the ninth repetition even four items are correctly reproduced. At the eleventh and twelfth repetition the number of correct items drops again to two, but rises up the next day to three The number of omissions is least in the seventh and tenth repetition Also, this subject has a greater tendency to stick to her story and the number of items taken over from the one story to the other rises even to nine in the eighth and ninth repetition The drop in the last two repetitions is evidently due to the emotional factors which provoke her crying It seems that her emotions destroy the comparatively stabilized pattern she had reached between the eighth and tenth repetitions

The complete scheme gives a better insight into the processes going on The number of words omitted from the original story remains quite constant, but the number of added words is continually decreasing Substitutions of words by words with a more general meaning are common, as are substitutions by words which are more common Individual names are changed. Sometimes more moral words are used Sometimes synonyms are used

Perseveration of mistakes plays an enormous part We reproduce in the appendix several more protocols which merely emphasize the principles that we have discussed, as we used this method in a comparatively large series of cases.

DISCUSSION

When the story has been read to the individual an impression must have remained This impression is the basis for the recall According to our experimental procedure all recalls have to go back to this primary impression We may call this impression the memory trace. It is easy to see that every recall is different from the preceding one. We may form the opinion that the trace remains constant and that every recall brings different sides of the trace into appearance. It does not seem very likely that the trace should be stabilized It is much more probable that the trace itself undergoes an organization and that the recalls merely register the organization which takes place. It is true that the experiences of psychoanalysis make it very probable that traces have a much greater stability than one usually supposes. The *psychoanalytic method* can unearth traces based upon experiences in very early childhood. Memory consists, as Freud has emphasized, of two different systems: the one system retaining the trace in its original form, the other system consisting of an elaboration of the original trace by condensation, transposition and symbolization. Experimental studies by one of us (Schilder) have led to identical conclusions. The great persistence of original traces appears also in experiments in hypnosis in which seemingly forgotten material can be brought forward. The trace and its recall can be separated from each other but only artificially. It depends upon the total situation which part of the memory material can be utilized. We come, therefore, to the conclusion that we deal in our experiments not only with changes in the recall, but also with changes in the organization of traces. Our experiments show clearly that a change in the trace from repetition to repetition does not consist merely of a fading of the trace and the lessening of its efficiency. It occurs in our protocols again and again that words and sentences which were not available at a previous recall become available at a latter recall. Even from one day to another an improvement in the recall may take place. The change is insufficiently described by the mere hint of quantitative changes in the trace. To be true there are some general characteristics. The greatest loss in the efficiency of the trace occurs very often in the beginning during the first, second and third recall. However, even the first recall shows already signs of a very active mental process. Phrases are substituted by similar phrases, words are substituted by synonyms, by more general or by more specific terms and by words which are more or less common. All shades of emotion express themselves in the series of recalls in the choice of words. It is obvious that a total personality is involved in the processes of the organization of phrases in which the verbal formulation plays a very important part. With the continuation of the recalls it becomes obvious that the individual who has once organized a trace has a decided tendency to stick to this organization which originates seemingly from the individual attitude. The right columns of our tables show clearly how much the individual intends to stick to his version. We may speak about perseveration. In all our protocols the individual tends to come to a relative stabilization of the process of organizing the traces. It is obvious from our protocols, especially from the right columns, that the activity of the organization diminishes and the changes become rather stabilized. A definite pattern is formed. This pattern is only relatively and not absolutely stable. It seems that the individuals are rather willing to go on with repetitions until this pattern is reached, and that then unwillingness to go on is very closely related to a definite formation of the pattern. The emotion and the organization are merely two sides of the same fundamental process which leads to saturation. We deal with a process of great activity which, according to our opinion, merely reflects what is going on with every trace. The memory traces in these experiments show also very clearly the forces which are paramount in verbal development and verbal formulation. We found an outspoken tendency to substitute specific and rare words by more common words. There is a leveling tendency in language.

PART II

We were interested to compare the results obtained in normals with the results obtained in pathological cases. Table 5 represents material from a schizophrenic girl. It is obvious from one look at Table 5 how little the patient is interested in the material offered to her and after the third repetition no item of the story is utilized, not even in a changed way. The patient still remains interested in her own production and 40 items are taken over from her third repetition to her fourth repetition, but eventually she does not even keep up the interest in her own story. We reproduce the first and the fifth repetition.

TABLE 5
HELEN M

	I	II	III	IV	I	II	III	IV
1	0	9	15	20				
2	0	0	24	46	0	0	9	44
3.	0	5	19	53	24	5	24	21
4	0	0	24	112	40	5	5	39
5	0	0	24	48	8	8	66	16
6	0	0	24	25	0	0	32	18

> *First trial.* Mr. Moore has deliberately let a match toss away and set 5-6 people on fire. That was in San Francisco. I believe he's still in jail yet. I believe that Mr. Moore the

> District Attorney ordered the investigation to keep him in jail for tossing a match and setting a bomb and killing so many people I can't memorize that It's impossible I'm giving my *statement as far as what you said*
>
> *Fifth trial* I don't even know the man I am just guessing in my own mind What's the idea of doing this? Just to pass the time I don't know any more he is out of office six years I remember the train, the bomb and he being arrested three *hours after He was 17 years in jail* Oh yes, I think he was married I believe on account of the people accusing him it was because of his wife and home. He was a pretty young man when he went in but he is pretty old "bugger" now, but still he is able to hold a job in the bank and support his family No more now I have to beat it

This is a clear cut instance of an individual who is less interested in the recall of the trace than in expressing her own emotional trends

More relevant to the topic are the results in cases with memory disturbances on an organic basis We add a protocol of a 42-year old woman with severe memory disturbances of an organic type The nature of the organic process from which she was suffering could not be ascertained. The patient showed no tendency to confabulation The story had to be read to her two times before she could be induced to repeat the story.

> 1 Olaf Nelson died from burns from a lighted match from his skirt
>
> 2 Olaf Nelson died from burns from a lighted match from his skirt.
>
> 3, 4, 5 *Repetitions are identical in spite of the urging of the experimenter*
>
> *6, 7, 8, and 9 Repetition* for his skirt *is substituted by* to his skirts
>
> *After the ninth repetition the patient complains* It is hard to repeat it when you merely hear it
>
> *The patient is now ordered to read the story herself aloud*
>
> *The tenth repetition, however, is still identical*
>
> *At the eleventh repetition, the patient adds,* Moore died from the burns of a match lighted in a dance comedy hall
>
> 12 Wilson, what's his first name, Olaf, Odolf Wilson died from burns from a match that lit his skirts.
>
> 13 Odolf Wilson died from burns of a match that lit his skirts in a comedy dance hall

> 14. *Identical*
>
> 15 *Identical but omits* in a comedy dance hall
>
> 16, 17 *Identical to 15*
>
> 18 Olaf Wilson died from burns from a lighted match to his skirts
>
> 19 to 24 *Identical*
>
> 25 *The examiner tells her* take your time, tell the whole story *The patient repeats and adds,* that occurred in a comedy dance hall *Asked whether her report is correct she says* Wilson comes in somewhere.
>
> 26, 27 *Identical to 24*
>
> 28 *She adds* In a comedy dance hall. *Urged whether the story is complete she adds,* Who is this, who was produced; manslaughter, he was charged with manslaughter?
>
> 29. *Identical Patient adds* I was thinking who was charged with manslaughter Wilson was it, was it not? He was the cause of the matches, manslaughter that is more of a hit, more of a fight

The patient is given an hour pause and repeats then the story as follows.

> Adolf Wilson died from burns that set his skirt on fire It occurred in a dance hall (How did that happen?) He evidently had something explodable about his clothing. The matches exploded and the skirt got on fire That occurred in a dance hall academy (What did the other people say?) Wilson was charged with manslanghter (Who charge him?) Officials I presume (The patient does not think she has memory defects)

Since the technique of examination had to be changed in this case, we have refrained from tabulating it. The perusal of the protocol shows very clearly that the same processes which go on in the normal are present, too, in the pathological case but merely in an exaggerated way. It is particularly obvious in this case that a definite pattern is prematurely formed and then kept with a great tenacity, but individual names, words, and items are also radically changed It is also obvious that it depends on the circumstances how much of the existing traces can be utilized by the patient.

We come to the conclusion that the pattern formation present also in the normal can be accelerated in cases of organic memory disturbances Many of the other changes are qualitatively identical with the changes which take place in the normal but they are more outspoken. We have, furthermore, studied in detail several cases of Korsakoff's psychosis. We reproduce the protocol of one of these cases (Table 6). The table shows very clearly that the patient has retained only very little of the original story, but still after the 16th repetition one item is still correct and two are changed A great productivity in producing new items is obvious when one looks at *IV* on the left column The column on the right side shows very clearly that the patient has a greater tendency to stick to the items he has invented himself

TABLE 6

J R

	I.	II.	III.	IV	I	II	III	IV
1.	1	2	21	46				
2	0	1	23	25	0	3	40	21
3	1	1	22	22	12	4	15	5
4	0	1	23	22	10	2	16	7
5	1	2	21	33	10	2	9	29
6	1	2	21	18	11	1	23	11
7	1	3	20	17	11	1	7	10
8	1	1	22	27	7	4	13	16
9	0	1	23	21	7	3	15	12
10	0	2	22	16	3	4	16	7
11	1	2	21	12	3	3	9	7
12	0	2	22	16	9	6	5	8
13	1	2	21	17	9	6	1	10
14	1	2	21	14	9	5	7	4
15	1	2	21	22	10	3	3	14
16	1	2	21	20	8	5	5	8

The tabulation with the complete scheme cannot give a definite idea of the mental productivity of the patient and we omit, therefore, its reproduction. A part of the protocol is here reproduced:

> *First trial* A man named Nelson attended a hula dance and while there lighted a cigarette After taking a puff of the cigarette he deliberately threw the remnant of the partly smoked cigarette into the crowd—not deliberately He misjudged the direction where he stood and the outer edge of the spectators What happened, I don't know. How would you finish it? The police were called who sent hurried calls for ambulance and those badly burned were rushed to the hospital The man who threw the cigarette butt was taken to the station house for examination for insanity His name he said was John Nelson,

> age 38, living at , and , I am making this up, father of three children.
>
> *Third trial.* Harry Nelson, 28 or 38, is under arrest to-day charged with throwing a lighted match butt into a throng of spectators. I have said that before. He was held for examination as to insanity. He is a well-known resident of his community . . . I have said that before.
>
> *Ninth trial.* In repeating for the third time under protest Harry Nelson, 20 years old, a resident of the district was arrested for throwing a lighted butt into a crowd of spectators . I am unable to say word for word what I said into further versions of Nelson's act. I have made a note.
>
> *Eleventh trial. The patient protests again vigorously against continuing.* John Nelson is under arrest to-day charged with throwing a lighted cigarette butt and match into the midst of of a nearby crowd gathered to listen to him or to another lecturer.
>
> *Fifteenth trial: The patient protests again vigorously saying,* In Bellevue Hospital the doctors are more crazy than anybody else in the observation world. John Nelson, 28 years old, a resident of this neighborhood, is arrested to-day, charged with throwing a lighted cigarette butt and match into a crowd of spectators. To-day he is held under arrest and held for observation.
>
> *After the 16th repetition the patient protests again vigorously.* Do you like to tell the same story twice? *He continues after a pause of ten minutes and repeats now the story as follows:* John Nelson, age 28, under arrest to-day charged with throwing a match into a crowd of spectators. He was held for police and observation. (*The patient is a newspaper man.*)

Studying such a protocol carefully one will find that traces are formed also by these patients. In the different trials different parts of the traces are utilized. The pattern formation is rather obvious. In some of his previous protocols pattern formation was overshadowed by a wealth of new details invented by him, but could be recognized too. The variations and swings, the antepositions, postpositions and substitutions found in the normal can be found here, too; the swings are more outspoken here however. Perseveration so closely related to pattern formation plays an important part. It is obvious that we deal also in this case with a very active process of organization. This organization is much more determined by the individual attitudes of the patient than by the character of the material. We know from other studies that in cases of this type a tendency exists to take everything out of a story which might be offensive. There is a tendency to a happy ending Furthermore the individual experiences are mixed with the objective pattern. It is obvious that any attempt to characterize such a process merely as a difficulty in retention is erroneous One deals with processes of organization which are, in comparison to the normal, accelerated and exaggerated One gets the impression that the processes organizing the trace are less controlled and more under the influence of the individual attitude of the patient.

CONCLUSION AND SUMMARY

We have read to a great number of normal subjects a story once and have asked them to repeat the story until they were exhausted and refused to go on. Besides the omission of words and items, the following changes were observed: A phrase is substituted by a similar phrase; a phrase is added to the story; phrases are added expressing attitudes of the subject (impatience, disgust and uncertainty, and jocular, rebellious and gabby moods), substitution of a word, either by a synonym, or by a word of a similar meaning occurs; substitution by a word with a more general or more specified meaning is noted, substitution by a more or by a less common word, or substitution by an emotionally stronger or weaker word or substitution by a more or less moral word are observed There were also perseveration of words and phrases, especially of mistakes Colloquialisms and depreciative terms were used Individual names underwent the same changes New words were added which did not substitute any other words. Words and items were omitted In the series of trials words, individual names and items once omitted later appeared Mistakes were corrected. Changes in the location of words and phrases in the sense of anteposition and postposition took place. These changes are not merely due to the fact that recalls are demanded, they indicate a process of the organization of traces. The change in the trace from repetition to repetition does not consist merely of the fading of the trace. One deals with a very active mental process in which the total personality and its problems are involved An organization of the trace which once has been developed has the tendency to persist and a relatively stable pattern is formed When the pattern is formed individuals become unwilling to go on. The emotion and the organizations are merely two sides of the same fundamental process *which leads to saturation. The processes described are probably* processes which take place in every trace and are of importance *for the understanding of changes in the use of words. In* cases of organic disturbances in the memory function, the processes or organization of the trace are accelerated and exaggerated. They are less controlled by the trace as such and more under the influence of the individual attitude of the patient These disturbances cannot be understood merely as defects in retention and in old memories

APPENDIX

Explanation of the Table

The left column contains the comparison with the original story. *The right column contains the comparison with the preceding repetition* The Roman numerals indicate the items.

I. *Number of items correctly repeated.*
II. Number of items changed
III Number of items omitted
IV. Number of items added.

The Arabic numerals indicate the number of the trial

Casimer V

	I	II	III	IV.	I	II	III	IV
1	11	11	2	10				
2	12	9	3	14	21	7	4	8
3	14	9	1	11	22	5	6	3
4	14	10	1	12	30	11	0	3
5	15	9	0	13	29	22	0	0
6	14	10	0	13	29	1	0	0
7	13	12	3	10	29	1	0	0
8	13	11	3	10	29	1	0	0
9	14	9	1	11	29	0	0	0
10	11	12	1	11	26	3	0	0
11	14	10	0	11	28	2	0	0

Susan McG

	I	II	III.	IV.	I	II	III	IV
1.	2	2	20	7				
2	1	2	21	4	2	1	8	7
3	3	4	17	2	0	1	9	4
4	4	2	18	3	4	0	1	2
5	1	1	22	8	1	0	5	5
6	3	0	21	4	3	2	1	3
7	0	0	24	8	0	1	7	6
8	0	0	24	8	0	0	7	10
9	2	0	22	11	3	6	1	3
10	1	3	20	14	5	2	5	0
11	2	1	21	5	5	1	1	1
12	0	0	24	5	2	0	5	3
13	1	4	19	6	5	2	0	3
14	1	4	19	2	1	3	6	2
15	5	3	16	9	8	3	0	6
16	1	4	19	3	6	0	11	1
17	1	2	21	4	3	3	1	2
18	2	4	18	2	4	3	1	0
19	5	2	17	5	4	3	0	1

Theresa M

	I	II	III	IV	I	II	III	IV
1	8	7	9	8				
2	9	8	7	4	8	1	7	10
3	8	7	9	5	12	2	5	1
4	4	7	13	26	2	3	3	27
5	6	5	13	6	9	4	18	5
6	9	8	7	11	11	3	3	9
7	5	6	13	3	11	1	8	1
8	6	6	12	3	11	3	0	1
9	6	8	10	4	10	4	3	3
10	7	6	11	4	12	1	3	2
11	7	7	10	2	11	1	2	1
12	7	7	10	2	13	0	0	0
13.	7	6	11	2	11	2	0	0
14	7	6	11	2	12	1	0	0
15	7	7	10	2	17	1	0	0
16	7	7	10	2	17	1	0	0
17	7	6	11	2	13	0	0	0

EXPLANATION OF THE TABLE

The left column contains the comparison with the original story The second column contains the comparison with the preceding repetition The number in the left corner indicates the number of the trial. The vertical column of numbers point to the respective number of the complete scheme. The number of (x) signs indicates the approximate frequency of the change indicated by the number.

MARY S

1		2		3	
1a = 66		1a = 66	1b = 80	1a = 66	1b = 56
1c = 80		1b = 80	1c = 56	1b = 56	1c = 61
2 = 70		1c = 56	2 = 50	1c = 61	2 = 50
3 = 56		2 = 50	3 = 70	2 = 54	3 = 45
6e xxxxxx		3 = 60	5 x	3 = 59	6e x
19 xxxxx		6f x	6e x	6e xxx	21 xxxx
20 xxx		19 xxxxxxx	6f xx	19 xxxx	
		20 xxxxx	7 x	20 xxxx	
			10 x		
			12 x		
			19 x		
			21 x		
4		5		6	
1a = 66	1b = 61	1a = 66	1b = 33	1a = 66	1 b = 39
1b = 61	1c = 33	1b = 33	1c = 39	1b = 39	1c = 63
1c = 33	2 = 20	1c = 39	2 = 30	1c = 63	2 = 40
2 = 29	3 = 48	2 = 35	3 = 24	2 = 60	3 = 16
3 = 62	6f x	3 = 62	19 xx	3 = 63	6e xx
6f x	12 x	19 xxxxxxx	26 xx	6e xxxx	6f x
19 xxxxx	19 x	20 xxx		19 xxxx	12 x
20 xxx				20 xx	23 x

MARGARET C

1		2		3	
1a = 66		1a = 66	1a = 66	1a = 66	1b = 29
1c = 28		1b = 28	1b = 28	1b = 29	1c = 27
2 = 5		1c = 29	1c = 29	1c = 27	2 = 0
3 = 43		2 = 5	2 = 1	2 = 4	3 = 2
5 x		3 = 44	3 = 28	3 = 43	21 xxx
7 x		5 x	12 xx	5 x	
19 xxx		12 xx		10 x	
20 xx		19 xxx		19 xxx	
		20 xx		20 xxx	
		25b x			
4		5		6	
1a = 66	1a = 66	1a = 66	1a = 66	1a = 66	1a = 66
1b = 27	1b = 27	1b = 25	1b = 25	1b = 25	1b = 25
1c = 25	1c = 25	1c = 25	1c = 25	1c = 25	1c = 25
2 = 7	2 = 0	2 = 7	2 = 2	2 = 7	2 = 0
3 = 48	3 = 2	3 = 48	3 = 2	3 = 48	3 = 0
5 xx	5 x	5 xx	21 xxx	5 xx	21 xxx
10 x	19 xxx	10 x		10 x	
19 xxxx		19 xxxx		19 xxxx	
20 xxx		20 xxx		20 xxx	
21 xx		21 xx		21 xx	

Margaret C (*continued*)

7		8		9	
1a = 66	1a = 66	1a = 66	1a = 66	1a = 66	1a = 66
1b = 25	1b = 25	1b = 25	1b = 25	1b = 32	1b = 32
1c = 25	1c = 25	1c = 32	1c = 32	1c = 25	1c = 25
2 = 7	2 = 2	2 = 12	2 = 7	2 = 7	2 = 0
3 = 48	3 = 2	3 = 46	3 = 0	3 = 48	3 = 7
5 xx	21 xxx	5 xx	6c x	5 xx	20 x
10 x		6c x	30 xxx	10 x	21 xxx
19 xxxx		10 x		19 xxxx	
20 xxx		19 xxxx		20 xxx	
21 xx		20 xxx		21 xx	
		21 xx			

10		11		12	
1a = 66	1a = 66	1a = 66	1a = 66	1a = 66	1a = 66
1b = 25	1b = 25	1b = 25	1b = 25	1b = 25	1b = 24
1c = 25	1c = 25	1c = 24	1c = 24	1c = 25	1c = 25
2 = 7	2 = 0	2 = 6	2 = 2	2 = 7	2 = 0
3 = 48	3 = 0	3 = 48	3 = 3	3 = 48	3 = 0
5 xx	21 xx	5 xx	10 x	5 xx	5 x
19 xxxx		10 x	21 xx	10 x	21 xx
20 xxx		19 xxx	23 x	19 xxxx	
21 xx		20 xxx		20 xxx	
		21 xx		21 xx	

13		14		15	
1a = 66	1a = 66	1a = 66	1a = 10	1a = 66	1a = 66
1b = 25	1b = 25	1b = 25	1b = 25	1b = 25	1b = 25
1c = 25	1c = 25	1c = 25	1c = 25	1c = 25	1c = 25
2 = 7	2 = 0	2 = 7	2 = 0	2 = 7	2 = 0
3 = 48	3 = 0	3 = 48	3 = 0	3 = 48	3 = 0
5 xx	21 xx	5 xx	21 xx	5 xx	21 xx
10 x		10 x		10 x	
19 xxxx		19 xxxx		19 xxxx	
20 xxx		20 xxx		20 xxx	
21 xx		21 xx		21 xx	

TESSIE T

1		2		3	
1a = 66		1a = 66	1a = 66	1a = 66	1a = 66
1b = 0		1b = 44	1b = 44	1b = 24	1b = 24
1c = 44		1c = 24	1c = 24	1c = 28	1c = 28
2 = 18 (26)		2 = 2	2 = 1	2 = 18	2 = 17
3 = 40		3 = 44	3 = 21	3 = 56	3 = 13
5 xxxxxxxx		10 xxxx	5 xxx	5 xxxx	5 x
6e x		12 x	20 xx	6e x	20 xxx
12 xx		20 xxx	21 x	10 x	
19 x		23 xxxx	22 x	20 xxx	
20 xxx			23 xx		
25a x					
26 x					

Tessie T (*continued*)

4		5		6	
1a = 66	1a = 66	1a = 66	1a = 66	1a = 66	1a = 66
1b = 28	1b = 28	1b = 31	1b = 31	1b = 32	1b = 32
1c = 21	1c = 31	1c = 32	1c = 32	1c = 35	1c = 35
2 = 19	2 = 12	2 = 16	2 = 11	2 = 21	2 = 11
3 = 54	3 = 9	3 = 50	3 = 10	3 = 52	3 = 8
5 xxxx	5 xxx	5 xxxx	5 x	5 xxx	5 x
6b x	6b x	6e x	6e x	6e x	6e x
10 x	20 xx	10 x	20 x	10 x	20 x
20 xxxx	25b x	20 xx	21 x	20 xxxx	21 x
		21 x			
		23 xx			
7		**8**		**9**	
1a = 66	1a = 66	1a = 66	1a = 66	1a = 66	1a = 66
1b = 35	1b = 35	1b = 22	1b = 22	1b = 32	1b = 32
1c = 22	1c = 25	1c = 32	1c = 32	1c = 30	1c = 30
2 = 7	2 = 2	2 = 12	2 = 17	2 = 16	2 = 2
3 = 51	3 = 15	3 = 40	3 = 17	3 = 52	3 = 28
5 xxxx	21 xxx		5 xxx	5 xx	5 x
10 x			20 xx	6e x	21 x
20 xxxx			21 xx	15 xxxx	
21 x				21 xx	
10		**11**			
1a = 66	1a = 66	1a = 66	1a = 66		
1b = 30	1b = 30	1b = 23	1b = 23		
1c = 23	1c = 23	1c = 24	1c = 24		
2 = 9	2 = 0	2 = 10	2 = 0		
3 = 52	3 = 0	3 = 54	3 = 0		
5 xxx	20 x	5 xxxx			
10 x		10 x			
20 xxxx		20 xxxx			
21 xx		21 xx			

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THE MECHANISM OF VISION. XIV VISUAL PERCEPTION OF DISTANCE AFTER INJURIES TO THE CEREBRAL CORTEX, COLLICULI, OR OPTIC THALAMUS[*][1]

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In several studies dealing with the functions of the area striata of the cerebral cortex of the rat abnormal behavior was noted in animals subsequently found to have sustained accidental injuries to the superior colliculi in addition to the lesions within the striate cortex. The primary symptom in these cases was a great reluctance to jump in tests for detail vision which required them to cross a 20 cm. space. In two experiments (Lashley, '31; Lashley and Frank, '34) about 10 per cent of the animals could not be induced to jump after operation, and this behavior proved to be certainly diagnostic of invasion of the superior colliculi. Layman ('36) undertook a systematic study of detail vision in animals with lesions restricted to the superior colliculi. He found that, when finally trained to jump, such animals showed no disturbance in ability to distinguish simple visual patterns.

Evidence that movements of ocular convergence are influenced by a center in the superior colliculus (Bechterew, '09) suggest that the disturbance in jumping might be due to interference with fixation and the perception of distance.[2] To test this a study of reactions to visual distance by animals with injuries in the optic thalamus and midbrain has been carried out. Analysis of lesions produced in attempts to destroy the colliculi and optic thalamus revealed invasion of other

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[1] These experiments were completed at the University of Chicago and were aided by a grant from the Otto S. A. Sprague Memorial Institute.

[2] In discussing the connections of the optic thalamus of higher forms Brouwer ('27) has stated that, "The connection of the pulvinar with the gyrus angularis makes it possible that it has something to do with the movements of the eye muscles and with the higher visual functions (stereoscopic vision, the recognition of the relative and absolute distance)." Although the pulvinar is not developed as a distinct structure in the rat, Clark ('32) considers that its homologue is the pars posterior of the lateral nucleus, to which therefore similar functions may be ascribed.

thalamic nuclei, especially of the ventral and lateral groups. It was therefore necessary to control the effects of such injuries. Since these nuclei undergo virtually complete retrograde degeneration after destruction of their cortical projection fields, the most feasible method of testing their function in depth perception was by destruction of cortical areas. A number of animals with cortical lesions outside of the visual areas were therefore tested in depth perception and their brains were analyzed for retrograde degeneration in the thalamus.

METHODS

The apparatus of Lashley and Russell ('34) was used to determine the accuracy of depth perception. This apparatus records the horizontal component of the force exerted by the rat in jumping across a variable gap to a platform which presents only visual cues.

Normal pigmented rats were trained to jump and given five practice jumps at each 2 cm. interval from 20 to 40 cm., to reduce practice effects in later trials. This practice was followed by an initial test series to determine accuracy of discrimination. The test series consisted of five jumps at each centimeter interval from 20 to 40 inclusive. The distances in successive trials were varied in irregular order such that longer and shorter distances were alternated and no two consecutive distances differed by less than 5 cm. Twenty-one trials, one jump at each centimeter interval, were given daily for five days.

After the initial test series the animals were subjected to an operation involving injury to the optic thalamus or colliculus, or to the cerebral cortex in the control group. Two weeks after operation a second test series like the first was given, after which the animals were brought to necropsy. Comparison of the pre- and postoperative scores gives a measure of the loss or gain in accuracy subsequent to the operation.

Scoring. A rank-difference method was used for scoring the results. The average force for the five jumps at each distance was computed.[3] The averages were arranged in rank order of magnitude and the ranking compared with the rank order of magnitude of the

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[3] The use of five trials as a basis of comparison is purely arbitrary. Since chance variations in motor adjustment affect the score, it is obvious that the apparent accuracy will increase with the number of trials included in the averages.

TABLE 1

The Relation of Force to Distance for the Two Animals Making the Best and Poorest Scores in the Tests The distances are given in centimeters from 20 to 40 The forces are in scale readings which have a constant relation to dynes of force exerted Each is the average of 5 tests

Distance	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	Σdx
Force																						
No 9	55	52	60	67	65	75	66	80	79	85	89	88	94	99	97	102	104	106	113	112	114	16
No 10	73	77	91	84	89	74	93	86	96	99	85	94	95	106	87	92	94	100	89	101	98	86

distances. The sum of the differences in rank (Σdx) was taken as a measure of accuracy. These figures may be interpreted roughly in terms of differential sensitivity by reference to Table 1 which gives the best and poorest scores made in the tests. The best score ($\Sigma dx=16$) represents an average displacement in order of about one place which is what would be expected, if the limen lay between 1 and 2 cm., as Russell ('32) determined it for normal animals by other methods of analysis. Computation of the average score for 2 cm. intervals for this animal gives a perfect correspondence of force with distance.

The poorest score ($\Sigma dx=86$) represents an average displacement of four intervals or an average limen of about 4 cm. Averaging the force for 3 cm. intervals gives one reversal of order (at the greatest distance), or a threshold below 3 cm. over the greater part of the range.

Even the worst score is far better than chance which gives a figure above 200 for Σdx, so that in all the tests there is evidence for discrimination of distances. Rank order correlations between force and distance have also been computed and are given for comparison. For postoperative scores they range from 0.64 to 0.98, showing in another way a significant differential sensitivity for even the worst cases.

Operation. Operations were performed under ether anesthesia. The cerebral lesions were made with thermocautery. For destruction of the colliculi and optic thalamus a small trephine hole was made in the parietal bone of each side near the occipital angle. A thin knife was passed through the longitudinal fissure in an attempt to undercut the superficial structures of the thalamus or midbrain roof. This approach usually involves a slight injury to the inner margin of the hemisphere in the projection field for the lateral and anteroventral thalamic nuclei, but such lesions alone have not been found to disturb visual reactions to distance.

Reconstructions. Serial sections of the brains were prepared and stained with thionin. Camera drawings of the sections showing injuries were made and from these the dimensions of the lesions were transferred to the diagrams reproduced in Plates 1 and 2. The cerebral lesions were plotted by the usual methods of graphic reconstruction. The lesions in the optic thalamus and colliculi were projected on the diagram shown in Plate 2 which is from a camera

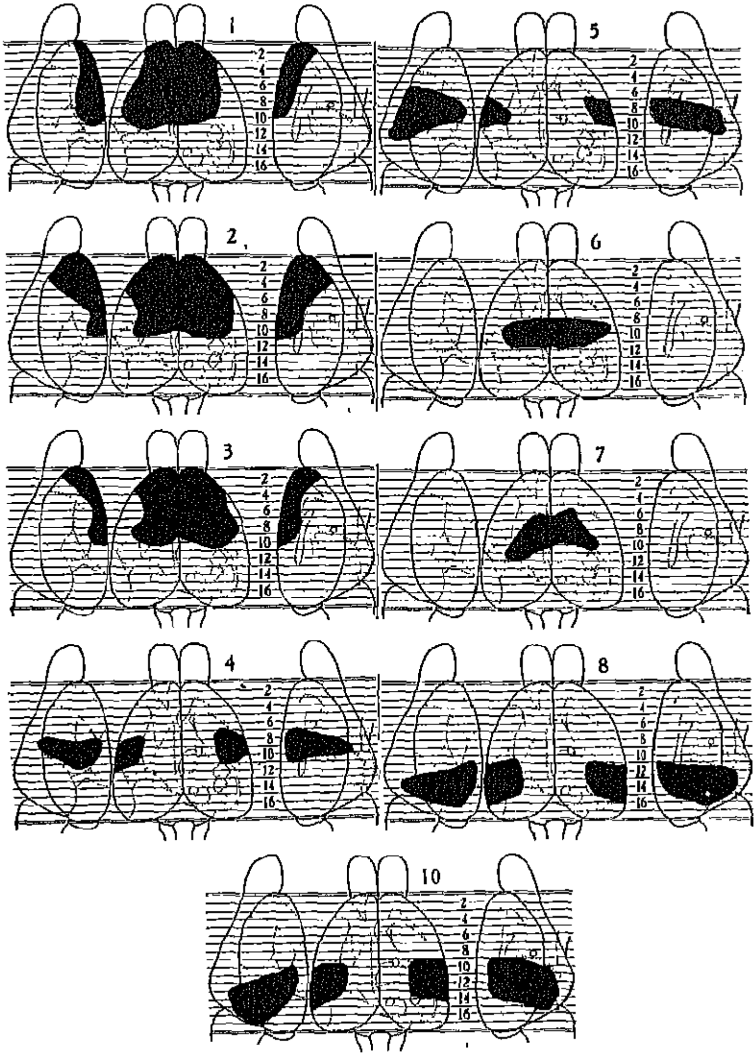

PLATE 1

Diagrams of the Cerebral Lesions from First Experiment

Numbers of figures correspond to numbers assigned to animals in tables 2 and 3

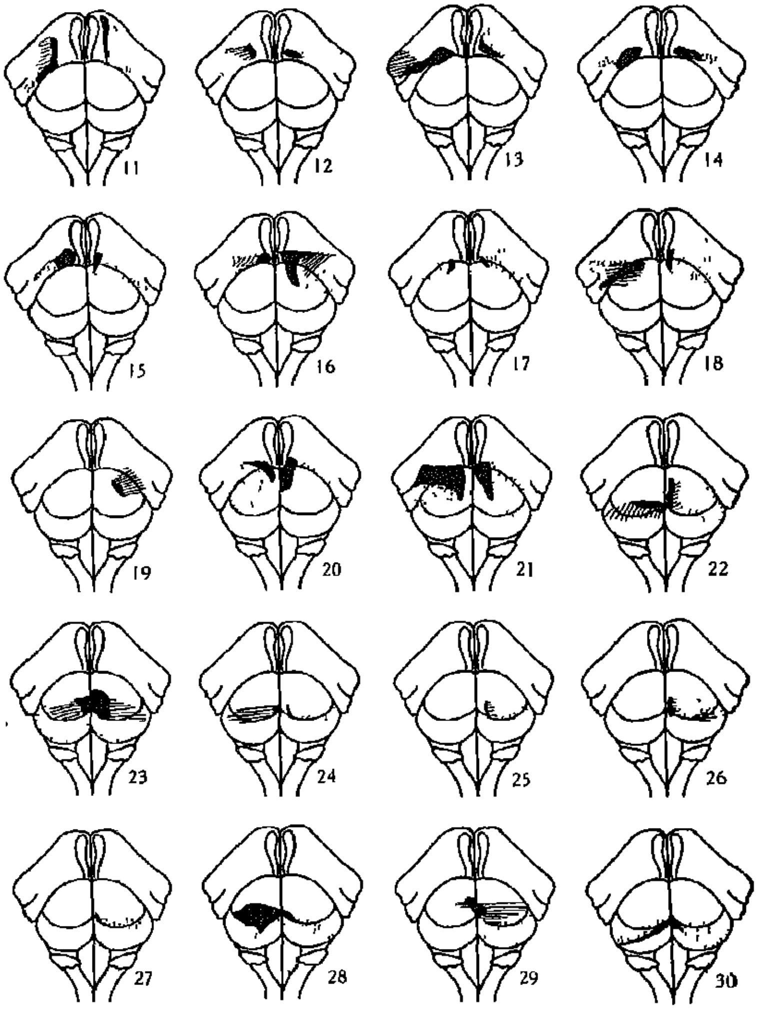

PLATE 2

Diagrams of Subcortical Lesions in the Cases Studied

The outline represents the thalamus, tectum, and medulla in proportions taken from a camera drawing. Complete destruction of surface structures is indicated in solid black, undercutting by stippling, and undercutting with degeneration of overlying structures by hatching. In practically all cases the cuts extend downward from the areas of superficial injury at an angle of about 30 degrees. The numbering of the figures corresponds to the numbers of the animals in Table 4.

drawing of a dissection of the thalamus and midbrain. In these diagrams destruction including the full depth of the optic structures is indicated in black, deep injury with degeneration of overlying tissues by hatching and deep undercutting by stippling. The lesions in sections appear as lines of scar tissue passing laterad and ventrad at an angle of about 30 degrees from the horizontal. Their character is illustrated in text Figure 1.

The Effects of Cerebral Lesions

Ten rats were tested for depth perception, subjected to operation on the cerebral cortex, and retested 10 days after the operation. Their scores are given in Table 2 and the reconstruction of the lesions in Plate 1. After the tests the brains were sectioned and analyzed for retrograde degeneration in the thalamus. The condition of the thalamic nuclei is summarized in Table 3. The terminology of

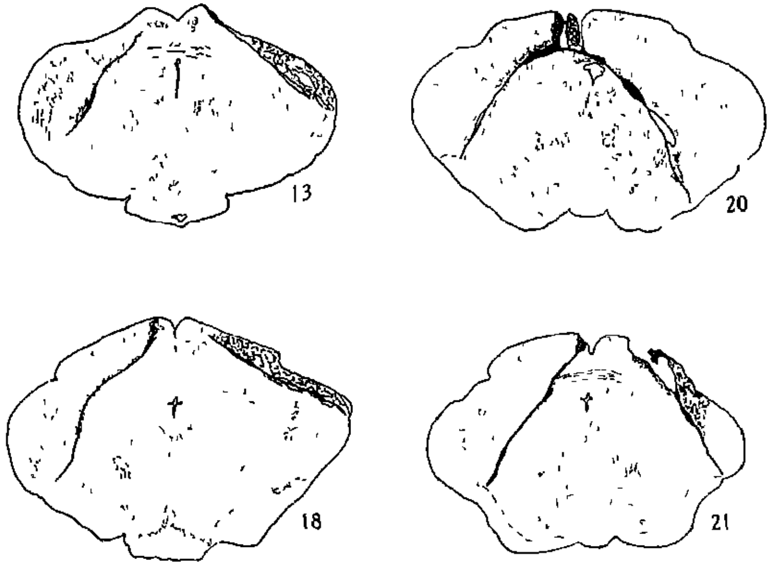

FIGURE 1

Semidiagrammatic Sketches of Sections through the Region of Maximal Injury in Four Representative Cases

Numbers 13 and 20 made the worst postoperative scores. Numbers 18 and 21, with greater involvement of optic structures, made normal postoperative scores.

TABLE 2

Pre- and Postoperative Records of Correlation of Force with Distance for Animals with Cerebral Lesions

Σdx, sum of deviations of order of force, p, rank order correlation of force with distance Under "field" the locus of the lesions is indicated in terms of Fortuyn's areas

No	Preoperative		Postoperative		Field
	Σdx	p	Σdx	p	
1	42	91	No jump in 60 days		*ff'*
2	37	90	No jump in 60 days		*ff'*
3	24	95	No jump in 60 days		*ff'*
4	31	94	34	90	lower *j*
5	31	94	63	80	lower *j*
6	29	95	32	95	upper *j*
7	78	66	36	94	upper *j*
8	71	73	64	77	*p*
9	22	96	83	68	*p*
10	33	95	No jump in 60 days		*p*

Waller ('34) has been followed The results conform quite closely to his schema of the cortical projection of the thalamic nuclei

In earlier unpublished studies we have found that lesions which involve the lateral portions of the striate areas seriously disturb or abolish reactions to visual distance The results for other areas, shown

TABLE 3

Thalamic Nuclei Showing Degeneration in the Animals with Cerebral Lesions whose Records are Given in Table 2

n, nucleus normal, +, nucleus severely degenerated, ±, gliosis with some cell loss, *n*?, some increase in glia with neurons apparently normal The terminology of Waller ('34) has been followed

No	1	2	3	4	5	6	7	8
Anteroventral	+	+	+	n	n	+	+	n
Anteromedial	±	±	±	n	n	n	n	n
Anterodorsal	n	n	n	n	n	n	n	n
Ventral anterior	+	+	+	n?	n?	n	±	n
Ventromedial	+	+	+	n	n	n	n	n
Ventrolateral	n	n	n	+	+	n	+	n
Arcuate	n	n	n	+	+	n	n	n
Centrum medianum	+	+	+	+	+	n	+	n
Lateral anterior	n	n	n	±	±	+	+	n
Lateral posterior	n	n	n	n	n	n	n	+
Lateral geniculate pars dorsalis	n	n	n	n	±	n	n	+
Medial geniculate	n	n	n	+	+	n	n	+

in Table 2, are quite consistent. Extensive lesions covering the electrostimulable areas (ff' of Fortuyn, '14) abolished the reaction. The animals with such lesions, Numbers 1, 2, and 3, were tested daily for two months after operation but could never be induced to jump. The thalamic nuclei degenerated were the same in all three cases and included the anteroventral, the anteromedial, the ventral anterior, the ventromedial.

Lesions in Field *j*, which Fortuyn interpreted as sensory (tactile-kinesthetic) had no effect upon the reaction. In Numbers 4 and 5 the lower portion of this area was destroyed without significant reduction in accuracy of jumping. The nuclei degenerated were the ventrolateral, the arcuate portion of the ventral, the centrum medianum, and the medial geniculate, this last through interruption of the auditory radiation. In Numbers 6 and 7 the dorsal parts of Field *j* with the caudal part of the motor area were destroyed. The thalamic degenerations characteristic of lesion in this region were in the anteroventral and lateral anterior nuclei. No decrease in accuracy was produced.

The third area explored was Field *p* of Fortuyn, in Cases 8, 9, and 10. Number 8 showed no decrease in accuracy after operation. In this case there was complete degeneration of the right lateral geniculate nucleus, pars dorsalis, and of the dorsal and lateral portions of the left, probably restricting vision largely to the right inferior nasal quadrant (Lashley, '34, Figure 6). Both medial geniculate nuclei and the pars posterior of both lateral nuclei showed severe degenerative changes. The brain of Number 9 was lost, but a sketch of the surface extent of the lesions made at necropsy shows a location and extent similar to those in Number 10. The injury must have involved the greater part of the optic radiations. In Number 10 the optic radiations were interrupted and both lateral geniculate nuclei completely degenerated. Detail vision was therefore absent.

Summary. In this series of cases disturbance of reaction to visual distance appeared only after severe damage to the optic radiations or destruction of the frontal cortex within the limits of the electrostimulable areas for the neck and fore legs. In cases which showed no significant disturbance of depth perception severe or complete degeneration of the following thalamic nuclei occurred: anteroventral, ventrolateral, arcuate, centrum medianum, anterior and posterior parts of the lateral, and the medial geniculate. The lateral nuclei and

TABLE 4

THE GRADUATION OF FORCE IN JUMPING WITH DISTANCE TO BE COVERED BEFORE AND AFTER LESIONS IN THE REGION OF THE OPTIC THALAMUS AND COLLICULI

The relation between the variables is expressed as the sum of the deviations of the rank order of force and distance (Σdx) and also as the correlation coefficient (ρ)

	Σdx		ρ		
No	preoperative	postoperative	preoperative	postoperative	
11	32	28	.95	.95	Interruption of optic tract along margin of left colliculus. Extensive bilateral injury to lateral, pretectile, arcuate, and medial geniculate n.
12	22	23	.97	97	Slight injury to both pretectile n
13	34	74	.92	71	Right optic tract severely damaged in front of colliculus Left lateral geniculate n destroyed Both lateral thalamic n. invaded
14	30	24	95	95	Both pretectile and left lateral, pars post degenerated Both arcuate n invaded
15	37	34	93	94	Cuts through pretectile, arcuate and medial geniculate n of both sides
16	34	68	.91	85	Narrow scars through both pretectile into medial geniculate n
17	40	52	91	.85	On right the scar passes just mediad to the arcuate with slight degeneration in the ventrolateral n On left a cut through lateral, pars post, into medial geniculate n.
18	61	60	78	.76	Complete destruction of left pretectile and lateral, pars post with interruption of tract Right habenula and arcuate n. involved
19	50	16	84	98	Injuries in both hippocampal lobes with only slight invasion of lateral margin of right superior colliculus
20	24	86	95	64	Deep cuts passing through pretectile n and just mediad to arcuate n.
21	22	33	97	95	Interruption of optic tract and destruction of lateral margin of superior colliculus on left Colliculus and median geniculate n undercut on right

TABLE 4 (*continued*)

22	44	20	85	.98	Right superior colliculus undercut Posterior margin of left destroyed
23	*32*	*36*	*95*	*.93*	Caudal halves of both superior colliculi destroyed Inferior colliculi undercut completely
24	60	42	77	.90	Caudal third of both superior colliculi undercut
25	42	42	89	94	Slight injury in left area striata, nasal field Caudal margin of right superior colliculus undercut
26	36	22	91	94	Slight injury in caudal third of right superior colliculus Superficial erosion of left
27	22	18	96	97	Narrow knife-cut through caudal margin of right superior colliculus
28	*26*	*38*	*95*	*91*	Caudal fourth of right superior colliculus destroyed Deep injury in left inferior colliculus
29	*52*	*62*	*86*	*.75*	Small median lesion in left superior colliculus Caudal third of right superior and all of right inferior colliculus undercut and isolated
30	39	28	93	95	Right inferior colliculus undercut, left injured superficially

medial geniculate nuclei always contained some normal cells, the others generally showed loss of all nervous elements We may thus conclude that none of these nuclei plays any significant role in the control of sensorimotor reactions to visual distance and that accidental invasion of them in attempts to destroy the optic thalamus cannot be held responsible for reduced accuracy in this performance

The Effects of Subcortical Lesions

Of the animals in which subcortical visual structures were destroyed three were discarded one because of an injured foot, one because of extensive lesions in both lateral geniculate nuclei, and one on account of an infected wound The scores of the remaining 20 animals in the pre- and postoperative tests are given in Table 4, together with brief descriptions of the lesions, which are also represented in Plate 2

The cases are arranged and numbered roughly in the order of the position of the lesions from the anterior margin of the thalamus to the inferior colliculi.

No animal showed a complete loss of ability to give a differential reaction to visual distance after the operation The worst postoperative score ($\Sigma dx = 86$), made by Number 20, shows accurate adjustment of force to distance for intervals of 3 cm , except at the greatest distance

The average score for preoperative tests for all animals is $\Sigma dx = 36$, for postoperative $\Sigma dx = 40$ The difference is not reliable Figure 2

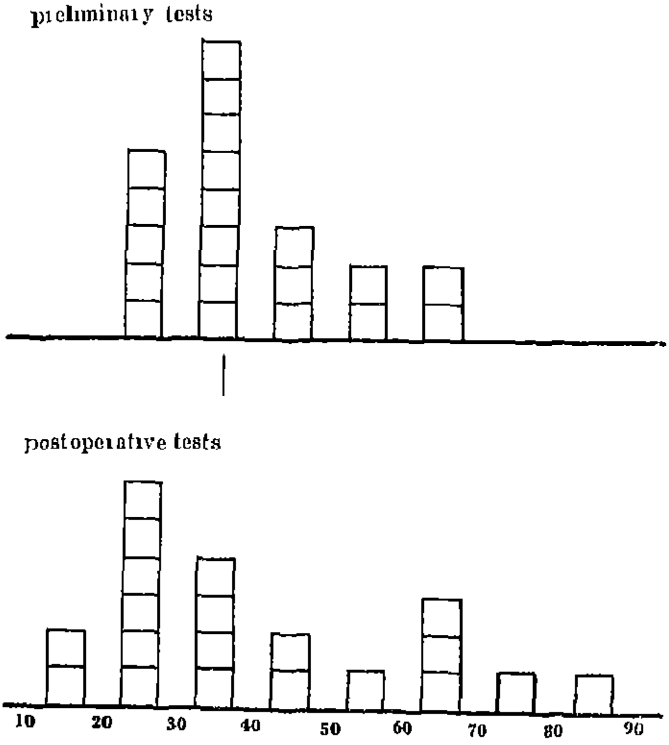

FIGURE 2

DISTRIBUTION OF SCORES (ΣDX) IN PRE- AND POSTOPERATIVE TESTS

The squares represent the numbers of animals falling within each class interval.

shows the distribution of scores The range of variation was significantly increased after operation Eleven animals showed increase, nine decrease in accuracy after operation These facts indicate that practice effects were not completely controlled by the initial practice

The average of preoperative scores of all animals was $\Sigma dx=36$. That for animals which showed improvement after operation was $\Sigma dx=41$. The average of postoperative scores for these animals was $\Sigma dx=30$. Only two animals which made better than average initial scores showed postoperative improvement and this was very slight in amount. We may therefore largely discount the practice effect as obscuring the influences of operation, since only the animals with poor initial scores improved and their improvement did not make them significantly better than the initial average of the whole group

In estimating the effects of the operation two variables must be considered, the amount of reduction in accuracy and the absolute accuracy following operation Thus Number 21 shows a 50 per cent reduction in accuracy in terms of Σdx, but only two per cent in terms of the correlation coefficient, and the postoperative accuracy is better than the average of normal animals In such a case we must conclude that the lesion has not involved any structure which is of primary importance for depth perception.

Cases showing significant loss Five animals show a postoperative reduction in accuracy large enough to be considered significant These are, in order of magnitude of the deterioration, Numbers 20, 13, 16, 17 and 29, with a range from 252 to 19 per cent increase in scores Numbers 28, 23, and 21 also show reduction in accuracy but their postoperative scores are not significantly worse than the average of all preoperative, so that they may be considered essentially normal

Number 29 made a poor preoperative record which became worse by 19 per cent after operation The lesion was in the posterior half of the superior colliculus with undercutting of the inferior (Plate 2, Figure 29) This case is controlled by Number 23 which had a more severe lesion in the same locus and made a postoperative score as good as the average of preoperative The slight loss and bad score in Number 29 therefore cannot be ascribed to the operation

The remaining cases which made significantly bad postoperative scores (20, 13, 16, 17) all have lesions in the same general region, along the anterior border of the superior colliculi In each case the knife entered the anteromesial border of the colliculus and passed laterad through the pretectile or lateral nuclei into the arcuate and ventrolateral or along the inner face of the medial geniculate nucleus The lesions are thus complex and difficult to evaluate The lesion is most extensive in Number 20 In the others (13, 16, 17) the same structures are involved with less extensive destruction

Number 21 provides a control for these cases In it the damage to optic structures was more severe than in Number 20 or any of the others of the group The optic tract and lateral margin of the right superior colliculus were completely destroyed on the right and the colliculus, pretectile and lateral nuclei invaded on the left Damage to optic structures more severe than in Number 20 was present also in Numbers 11, 14, 15, and 18, which showed no postoperative disturbance The poor scores made by Numbers 20, 13, 16, and 17 cannot be ascribed to the lesions in the optic structures

In Number 21 the cuts do not extend as far forward into the thalamus as in the animals which showed greater loss of accuracy In the latter the lateral nucleus, pars posterior, the arcuate, the ventrolateral and the medial geniculate nuclei were in some degree invaded. But in the tests of animals with cerebral lesions we have seen retrograde degeneration of all of these nuclei unaccompanied by disturbance of depth perception The deterioration in Numbers 13, 16, 17, and 20 therefore cannot be ascribed to the damage to thalamic sensory nuclei.

Magoun, Ranson and Mayer ('35) have shown that the path of the pupillary reflex to light decussates in part through the posterior commissure, so that damage to this structure must be taken into consideration in experiments on the visual functions of the thalamus Text Figure 1 shows interruption of the posterior commissure in animal Number 20, which showed maximal disturbance. It was also interrupted in Numbers 16 and 17, which made poor postoperative scores. But the posterior commissure was also cut in Number 12, with no postoperative change in threshold for distance, so that we must conclude that this structure is not concerned in depth perception.

Summary Thus for every case showing reduced accuracy of depth perception after lesion to a given thalamic or midbrain structure there are other cases with equally severe damage to the same structures and with normal or better than average normal records Also in terms of the amount of damage done, irrespective of the locus of the injuries, the postoperative scores are not related to the lesions Although a few animals showed what seems to be a significant reduction in accuracy of depth perception after the operation, it has been impossible to correlate this with any specific type of lesion.

INTERPRETATION

It seems clear from the above analysis that where a decrease in accuracy occurred it cannot be ascribed to injury to the optic tracts or centers. Injury to the sensory nuclei of the thalamus is also controlled. We must therefore ascribe the defects of behavior either to some general systemic effects of the operations apart from the brain injury or to damage to some unknown thalamic tracts. The latter interpretation seems improbable, since knife cuts tend to follow the course of major fiber tracts and seemed to pass through precisely the same regions in animals which did and did not show deterioration.

Our next question concerns the completeness of the survey of the subcortical optic structures covered by these experiments as a test of their function in depth perception. The projection of the retina upon the thalamus and colliculus has been worked out roughly by Overbosch ('27) for the rabbit and by Lashley ('34) for the rat, with results in essential agreement. The superior temporal quadrant of the retina is projected to the anterolateral quadrant of the colliculus, the inferior temporal to the anteromedial, the inferior nasal to the posteromedial, and the superior nasal to the posterolateral quadrants. How fine the localization within the quadrants may be cannot be determined by the Marchi technique used. The available evidence indicates that only the contralateral retina is represented in each colliculus.

Distribution of optic fibers in the lateral nucleus, pars posterior and in the pretectile nucleus corresponds to the most direct path to the points of termination in the colliculus. Thus the fibers from the superior temporal quadrant have the most lateral position and those from the superior nasal the most medial. Uncrossed fibers apparently reach the pretectile nucleus, but their source in the retina and distribution in the nucleus are not known.

Complete bilateral destruction of the optic thalamus or colliculi has not been achieved in this study. In Numbers 11, 18, and 21 the optic tract was completely interrupted on one side between the lateral geniculate nucleus and the colliculus without destroying capacity for depth discrimination. This operation should have been effective, if the colliculi participate in reactions to binocular parallax. Bilateral destruction of the projection areas of the colliculi for the inferior and the lower part of the superior temporal quadrants was obtained in Number 21 This covers the field of maximal acuity of the rat and did not abolish depth perception. Lesions in other cases with normal postoperative performance have covered almost every part of the optic thalamus, superior and inferior colliculi In Number 23 the peduncles of the inferior colliculi were completely severed. Only the lateral margins of the superior colliculi remain unexplored in bilateral operations The material was not prepared for study of fiber tracts, so that exact data on injuries to the lower connections of the colliculi are not available. The course of the major tracts, the tecto-spinal and tecto pontal, as described for the rat by Papez and Freeman ('30), is such that these tracts must have been destroyed in the majority of animals

In Numbers 11, 13, 17, and 21 the pars posterior of the lateral thalamic nucleus was severely injured on one or both sides without significant loss of accuracy in depth perception and in Number 8 of the cortical series these nuclei showed severe degeneration. In none of these cases was there a marked reduction in accuracy after the operation

The experiments leave open two alternative interpretations (*a*) The optic thalamus and colliculi do not participate in motor adjustment to visual distance. (*b*) These optic structures do contribute to the function, but the projection field for part of the superior temporal quadrant on one side is capable of mediating the function in a normal manner. This would correspond to my previous results with respect to the function of the binocular field of the striate cortex in detail vision (Lashley, '31).

Other experiments seem to oppose this second interpretation I have shown (Lashley, '35) that lesions of the type produced in this study, when combined with severe destruction of the striate areas, reduce or abolish the capacity to form habits based on discrimination of intensities of light, and Layman ('36) has confirmed this for combined lesions in the optic thalamus and lateral geniculate nuclei Since in these cases the destruction of the optic thalamus was not complete we must conclude that parts of the system are not capable of exercising the functions of the whole The problem is complicated, however, by our inability to demonstrate any visual defects after lesions in the optic thalamus and colliculi, so long as the geniculo-striate system remains intact[1] Final interpretation of the data must await the development of a better understanding of the interrelations of the striate areas and subcortical visual structures.

In the tests after cerebral lesions it is clear that interruption of the optic radiations interferes with or inhibits jumping This confirms earlier unpublished observations by Russell and Lashley that extensive injuries in the lateral halves of the striate areas (binocular projection fields) reduce or abolish the accuracy of adjustment of force to distance in the jumping tests It seems clearly established that the visual cortex is essential to the reaction

Interpretation of the effects of lesions in the motor areas is less certain The lesions in Numbers 6 and 7 involve the areas electrical stimulation of which induces movements of the hind legs (Lashley, '21) and in Number 7 this "motor area" for the hind legs was completely destroyed. This is also the region associated with postural adjustments of the hind legs (Bard and Brooks, '34) Control of the hind legs is essential for accurate jumping, yet removal of this hind leg area did not interfere with performance This fact supports my interpretation of earlier data to the effect that the mechanisms activated by electrical stimulation of the cortex are not those concerned with the initiation of adaptive movements (Lashley, '24) Yet the destruction of the frontal regions, including the stimulable areas for the head and legs without complete destruction of the hind leg area precludes jumping This result is seemingly an effect of the extent of destruction in the motor area

In these experiments relatively little difficulty was encountered in getting the animals to jump, in comparison with animals in previous experiments where combined lesions in the striate cortex and colliculi were involved It seems clear that the reluctance to jump shown by the earlier cases cannot be ascribed to a disturbance of depth perception arising from the injury to the subcortical visual centers

SUMMARY

The accuracy of visual discrimination of distance was tested for rats before and after operations involving the optic thalamus and colliculi The greater part of the structures, with the exception of the lateral margins of the colliculi, was explored in bilateral operations. The optic tract of one side was completely interrupted in the region of the optic thalamus in several animals. Although a few animals showed a significant reduction in accuracy of discrimination after operation it was impossible to correlate their behavior with any characteristic of the lesions. Animals with damage to the same structures and with more severe and widespread injuries made normal scores. The experiments give no evidence that the optic thalamus or colliculi play any part in the visual discrimination of distance.

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[1] Additional evidence on this point will be reported in a later paper of this series

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THE INFLUENCE OF PUNISHMENT ON LEARNING WHEN THE OPPORTUNITY FOR INNER REPETITION IS REDUCED*

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A previous investigation by Stephens (2) dealt with certain instances in which a subject has selected the wrong English word as the equivalent of a Spanish word and is automatically informed of his error. In that investigation it appeared that, contrary to the results of similar investigations by Thorndike [(3) Chap. XI], the subject was less likely to choose that same word in the future than he would have been had he received no information regarding his success or failure. It happened, however, that in Stephens' study the subject had considerable chance deliberately to memorize the success of his choices, perhaps repeating to himself "*hard* is not the answer to *durante*, *how* is not the answer to *hoy*" and so forth. In a private communication Professor Thorndike suggested that this possibility of drill or inner repetition might account for the difference in results. Later Thorndike published the results of an experiment (4) in which he had examined the influence of such inner repetition when a subject is told that he is right. It is difficult to judge the dependability of the figures but taking them at their face value it would appear that for nine subjects who claimed that they did not ordinarily employ such inner repetition, instructions to refrain from drill reduced the influence of "right."

It seemed wise to modify the experiment so that the opportunity for drill would be reduced as much as possible.

A second aspect of the first investigation also called for additional treatment. In that investigation the influence of punishment was greatest in the case of those connections which were initially strong enough to persist from one day to the next. This suggested the possibility that punishment worked "normally" on strong connections but had slight influence on connections that were not well established. In order to check this possibility we introduced an additional means of determining the strength or degree of certainty of the original choice

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PROCEDURE

Each subject was given the American Council Beta Spanish Test, Form *A* The test is of the multiple choice type On the first day subjects were told to underline the choice once if it was a guess, twice if it was a "hunch" and three times if they felt rather certain No information regarding the correctness of the choice was available at this sitting.

On the second day the subjects sat at a special table and viewed the questions as they passed under a slot This slot revealed at one time one line of print containing a Spanish word and the five English alternatives About 9 or 10 seconds elapsed between the emergence of the line from the bottom of the slot and its disappearance at the top. In this time the subject had to read the words, make his choice and with a stylus punch a hole through the word he selected As the stylus passed through the paper it completed an electrical circuit through a light which revealed through the paper and directly under the word punched either an *R*, a *W*, a nonsense symbol, or a blank circle of light The punching could take place only near the top of the slot so that there would be very little time between the occurrence of the signal and the appearance of the next line

The procedure on the third day was precisely the same as that on the first day

APPARATUS

A table about 2½ feet by 4½ feet was built around a roller three inches in diameter and 4½ feet long, made of wood and centered on a steel shaft, which projected from each end (A large roller used to operate the canvasses on a grain binder proved excellent for this purpose) The roller was placed in the frame so that it ran longitudinally along the center of the table. Parallel to the roller but about 15 inches away from it on each side were strips of wood containing the mechanisms for activating the lights

The words were mimeographed on three separate sheets and these were pasted together to form one long sheet This sheet was thumb tacked to the roller and fed over the parallel strip under and between guides As the roller rotated, the sheet of paper was pulled across the strip of wood The table was so constructed that four of these long sheets could be attached to the roller at once, two coming in from each side. In this way four subjects could participate at one time.

On the back of the sheet of paper was pasted another sheet having on it the symbols *R*, *W*, nonsense symbol, or (in about half the cases) blanks They were printed in mirror image (simply by reversing the mimeograph stencils) and the two sheets pasted together back to back The sheets were arranged so that the symbol was directly under the corresponding word These symbols, obscured by two thicknesses of paper, could not be seen unless light was applied from behind the paper

In order to accomplish the lighting, one bank of five flashlight lamps was sunk in the wooden strip at the place where each sheet of paper was drawn across A contact was placed near each lamp in such a way that the light from the corresponding lamp revealed the symbol directly under a given word whenever the stylus punched through that word and touched the contact

A sheet of beaverboard covered the whole table In this beaverboard the four slots were cut, one over each bank of flashlight lamps A sheet of celluloid covered each slot. Holes drilled in the celluloid directly above the contacts, acted as guides

We might note in passing that this method of applying symbolic rewards and punishments proved to be very satisfactory It is simple and cheap (The chief expenses were $2.50 for the roller and $1 00 for flashlight lamps The rest of the material came from ordinary laboratory equipment Considerable labor was involved in preparing the sheets and pasting them together) By using a longer roller (such as those often used for awnings) or by coupling several tables together by gears or chain drives, any desired number of subjects could be accommodated at one time For those who find the more elaborate Lorge-Waits (1) apparatus too expensive, this device may be an acceptable substitute.

RESULTS

For each word punched on the second day we have data to answer the following questions

(*a*) Is this the word that was chosen on the first day?

(*b*) How certain did the subject feel of his first day's choice?

(*c*) What information did he receive on the second day after punching the word?

(*d*) Did he choose the same word on the third day?

The information in both items (*a*) and (*b*) is to help classify the choices into strong and weak connections.

Table 1 permits the comparison of the present experiment in which there was little opportunity for drill with the previous experiment in which drill may have taken place It will be seen that apart from two discrepancies, the results of the two experiments are surprisingly consistent. We note one discrepancy in the case of the influence of the nonsense symbol on weak connections. This difference of 10±3 9 is none too dependable but it does suggest that a meaningless symbol may be more likely to strengthen a weak connection when the time is limited than when the time is unlimited On the other hand the influence of the nonsense symbol on the strong connections seems unaffected by the reduction of time.

The other discrepancy concerns the chief point of issue in the experiment The influence of "wrong" on strong connections is markedly less when the opportunity for drill is reduced In fact when drill is restricted the value for "wrong" is only 6±2 6 or 8±3 1 less than the value for the blank light or the nonsense symbol respectively. That is to say there is some room for question as to whether wrong has *any* deterrent effect on the strong connections when the opportunity for drill is reduced.

In the second part of our problem we wished to see if a different measure of strength would reveal any more definite relation between the strength of the connection and its susceptibility to punishment. Two criteria of strength were employed for this purpose, the one already used, i e, persistence from the first to the second day, and a second one consisting of the subject's rating of his degree of certainty These ratings were originally in one of three rubrics "guess," "hunch," and "certain" There were, however, very few choices rated as certain and these were lumped with "hunch" choices, giving us guess choices and choices better than guess Thus each choice could be classified as either persisting to the second day or not persisting and as either being better than guess or mere guess

The use of such a two-by-two classification necessarily reduces the number of cases in each cell This disadvantage may be overcome

TABLE 1

THE INFLUENCE OF DIFFERENT TYPES OF INFORMATION ON STRONG AND ON WEAK CONNECTIONS

	Strong Choices (Those Persisting from the First to the Second day)				Weak Choices (Those not Persisting from the First to the Second Day)			
Information Received After Second Day's Choice	No of Choices	No Persisting to the Third Day	Percent Persisting	Corresponding Percent for the Previous Study	No of Choices	No Persisting to the Third Day	Percent Persisting	Corresponding Percent for the Previous Study
Right	338	277	82±1.4	86±1.3	142	75	53±2.8	59±2.6
Wrong	234	143	61±2.2	51±2.1	144	47	33±2.6	30±2.5
Nonsense Symbol	210	144	69±2.2	69±1.8	139	63	45±2.8	35±2.7
Blank Light	635	421	67±1.3	65±1.3	361	141	39±1.8	36±1.9

TABLE 2

THE INFLUENCE OF DIFFERENT TYPES OF INFORMATION UPON STRONG AND WEAK CHOICES

		Strong Choices (Those Persisting from First to Second Day)				Weak Choices (Those not Persisting from First to Second Day)			
		College Students Only		College and High School Students		College Students Only		College and High School Students	
	Information Received After Second Day's Choice	No of Choices	% Persisting to the Third Day	No of Choices	% Persisting to the Third Day	No of Choices	% Persisting to the Third Day	No of Choices	% Persisting to the Third Day
BETTER THAN GUESS	Right	173	86	225	84	51	57	79	53
	Wrong	88	58	136	60	33	33	58	31
	Nonsense Symbol	91	68	113	66	37	46	53	43
	Blank Light	293	69	446	66	94	37	156	36
MERE GUESS	Right	165	78	242	76	91	51	192	48
	Wrong	146	63	230	60	111	32	211	37
	Nonsense Symbol	119	69	169	69	102	45	179	39
	Blank Light	340	65	557	63	267	40	532	36

to some extent by including data not given in Table 1. These additional data are probably not strictly comparable to the original data since they were obtained from high school students. Moreover two different rates of speed were used for different members of the high school students. Consequently there may be some doubt as to the wisdom of combining such data. For that reason we give the results for both college students alone and for college and high school students combined

In the case of neither the college students alone nor of the combined groups does there appear any marked or dependable tendency for "wrong" to operate more effectively on strong choices than on weak

As a supplement to Table 2 and as a condensed account of the data presented so far, we give in Table 3 a summary of the difference between the value of "wrong" and the value of the two controls The corresponding data for the first four lines in Table 3 come from Table 2 In the case of the last two lines, the corresponding data for the college students appear in Table 1, while in these two lines the corresponding data for the combined groups do not appear elsewhere

Table 3 bears out the view indicated by Table 1. Although in the comparisons indicated by an asterisk we find differences more than 2.5 times their probable errors, in no case can we be *reasonably sure that "wrong" really weakens a connection.* Of course with several types of comparisons yielding differences bordering on significance, some influence is strongly suggested

SUMMARY

In a previous experiment which permitted considerable opportunity for drill or inner repetition it was found that punishment (a signal for "wrong") definitely weakened initially strong connections When that experiment was repeated with the opportunity for drill or inner repetition reduced, the strong connections were much less influenced by punishment In fact, though some influence of punishment was suggested in most types of comparisons, in none of these do we find the influence of "wrong" to be significantly different from that of the controls.

TABLE 3

THE DIFFERENCE BETWEEN THE INFLUENCE OF WRONG AND THE INFLUENCE OF THE NONSENSE SYMBOL OR OF THE BLANK LIGHT RESPECTIVELY

		Strong Choices		Weak Choices	
		College Students	Combined Groups	College Students	Combined Groups
BETTER THAN GUESS	Non-Symbol minus Wrong	10±4.8	6±4.2	13±7.2	12±6.1
	Blank Light minus Wrong	11±3.9*	6±3.4	4±6.4	5±4.8
MERE GUESS	Non-Symbol minus Wrong	6±4.0	9±3.3*	13±4.5*	2±3.3
	Blank Light minus Wrong	2±3.2	3±2.7	8±3.6	—1±2.6
TOTAL	Non-Symbol minus Wrong	8±3.1*	8±2.6	12±3.8*	7±2.9
	Blank Light minus Wrong	6±2.6	4±2.0	6±3.2	3±2.2

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SHORT ARTICLES AND NOTES

SOME EXPERIENCES WITH THE PRESSEY X—O TEST USING A GROUP OF NORMAL ORPHAN CHILDREN IN A SUPERIOR INSTITUTIONAL ENVIRONMENT*[1]

HAROLD A KOHN[2]

In connection with a more extensive research program now in progress, 118 girls and 149 boys from the ninth through the twelfth grades of the Mooseheart High School were examined by means of the Pressey X-O Test, Form *B* The data were analyzed for sex and grade differences and for connections with behavior disorders Central tendency and reliability measures when the test is scored for "total emotionality" or "affectivity" (combined scores) by sexes, are given in Table 1

TABLE 1
SEX DIFFERENCES IN TOTAL EMOTIONALITY OR AFFECTIVITY

	N	Mean	Median	S D	S E	Q
Boys	149	142.95	146.55	38.54	3.15	30.52
Girls	118	143.81	145.00	41.38	3.81	24.45

The reliability of the difference between the two means in terms of the sigma of the difference is 4.94. The difference between the means is 86 points The $\frac{D}{\sigma \text{ diff}}$ is 17 It is thus clear that there does not appear to be any reliable sex difference as regards to the total emotionality scores *using the present sample* The reliability of the difference between the two medians expressed in terms of $\frac{D}{\text{P.E diff}}$ is 37 Again there does not appear to be any sex difference of a reliable character as regards the total emotionality scores of high school students in our situation Pressey finds such differences to be operative (1) In Table 2 our data are compared with those of Pressey in this connection

---

*Recommended by Martin L Reymert, and received in the Editorial Office on January 21, 1937.

[1] Mooseheart is an international school and home owned and operated by the Loyal Order of Moose for the care and training of dependent children of deceased members of the Fraternity

[2] My especial thanks and sincere appreciation are extended to Dr Martin L Reymert, the Director of the Mooseheart Laboratory for Child Research, for his invaluable advice and encouragement in this work

TABLE 2

COMPARISON OF PRESSEY AND MOOSEHEART DATA AS REGARDS SEX DIFFERENCES IN TOTAL EMOTIONALITY

Grades	*Pressey Norms*		*Mooseheart*		*Data*	*Medians*	
	Boys	Girls	N	Boys	N	Girls	Total N
9	171	171	37	158	20	170	57
10	164	167	38	150	41	143	79
11	159	163	25	143	12	150	37
12	158	162	51	139	43	141	94
							267

In analyzing the difference between the medians as given in the above table it is found that in no case does the $\frac{D}{\text{P.E. diff}}$ yield a reliability figure as great as 3.0. There appears to be no significant difference between the total emotionality or "affectivity" scores of boys and girls considered by grade, from the ninth through the twelfth year. It was thought that perhaps slight changes between girls' and boys' scores for the grades from 9 through 12 may reveal significant cumulative changes between grades. It is evident from Table 3 below that there does not appear to be any cumulative change between grades, indicative of a significant trend in the case of either sex.

TABLE 3

RELIABILITY OF DIFFERENCES OF BOYS' AND GIRLS' SCORES FOR THE DIFFERENT GRADES

	Grades	N	Median	$\frac{D}{\text{P.E. diff}}$	Chances in 100
Girls					
	9	20	170.00	.76	69
	10	42	142.50	.82	71
	11	12	150.00	.50	63
	12	43	140.83		
	9-11		170.00-150.00	.48	63
	9-12		170.00-140.83	.77	69
Boys					
	9	37	158.30	.87	72
	10	37	150.00	.80	71
	11	25	143.00	.46	62
	12	51	139.16		
	9-11		158.30-143.00	1.60	86
	9-12		158.30-139.16	2.07	92
		267			

Table 4 below summarizes the findings with respect to grade placement and total affectivity, as compared with the Pressey data It will be noted that while our data do not appear to be much different from the Pressey as to score, the trend is markedly different In computing the reliability of the median differences between successive grades for our data we in no case found a $\frac{D}{\text{P E diff}}$ as high as 4.0 The greatest reliability figure was 2 24 (93 chances in 100) between grades 9 and 12

TABLE 4
PRESSEY GRADE NORMS FOR TOTAL AFFECTIVITY COMPARED WITH MOOSEHEART DATA

	Norm		*Mooseheart Data*	
Grade	Median	Grade	Median	N
9	137	9	159	57
10	165	10	147	79
11	175	11	143	37
12	170	12	140	94
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Pressey states, "The tests should make a very convenient means for research in dealing with delinquents, neurotics, or other atypical individuals where disorders of the emotions and sentiments may be expected" (2). With this purpose in mind one of our clinical psychologists kindly assisted by selecting 41 boys and 15 girls, who had been referred to the Laboratory as in need of psychological care, to whom Pressey X-O Form *B* was administered Children referred for organic defect, or retardation in the school system due to low intelligence were excluded from this group The 56 children had been referred for general mal-adjustment, stealing, untrustworthiness and other behavior disorders similar to those found in any normal community The non-problem group consists of 102 girls and 114 boys The median scores for total emotionality of the behavior problem boys and girls respectively was contrasted with the median scores of non-problem boys and girls The findings together with the reliability of the differences in the medians for both groups are presented in Table 5 It is thus evident that no significant differences exist between problem and non-problem children using the Pressey X-O Form *B* when it is scored for total emotionality, and using the present sample

Due to the amount of labor involved, the test was not scored for deviations from the modal word The discrepancy between the Pressey and the Mooseheart data may then have two possible explanations (*a*) the test is unsatisfactory [this is admitted by the authors (3)], or (*b*) the present

TABLE 5

DIFFERENCES IN TOTAL EMOTIONALITY, PROBLEM AND NON-PROBLEM CHILDREN

N	Percent Problem	Median Scores	D P.E. diff.
Problem Boys 41	15.07	146	17
Non-Problem 114		145	
Problem Girls 15	5.51	135	1.46
Non-Problem Girls 102		144	
	20.58		

results may be conditioned by our peculiar environment, which by force of necessity, must be much more uniform than any sample taken from a general public school. It is probable that both factors are operative in conditioning our results. While Mooseheart may be regarded as a superior school and home environment, it should prove interesting to examine similar *samples in average orphanages elsewhere.*

CONCLUSIONS

1. Using the sample herein described there appear to be no significant sex differences in total emotionality or affectivity as measured by the Pressey X-O Test Form *B*.
2. No significant differences are apparent between scores of the high school students of successive grades.
3. This test, in our environment, does not reveal significant differences in the total affectivity scores of problem and non-problem children of either sex.

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Mooseheart, Illinois

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VALUATIONS OF CERTAIN PAINS, DEPRIVATIONS, AND FRUSTRATIONS*[1]

Institute of Educational Research, Teachers College, Columbia University

EDWARD L THORNDIKE

Better knowledge of the attitudes of people toward prospective "disutilities" in the form of pains, discomforts, deprivations, degradations, frustrations, restrictions, and other undesired conditions is obviously important The best approach is through direct observations and experiments, and we plan to make such But the opinions of persons concerning their attitudes are by no means valueless, if used reasonably For example, the answers reported to the set of questions printed below by various individuals are instructive in a number of ways (The two numbers after each item did not appear on the list as it was read by the person, they are inserted here for economy's sake and represent the median demand by a group of 60 students and teachers of psychology and by a group of 39 unemployed men and women, under 30 years of age, mostly college graduates. But it will be best if the reader pays no attention to these numbers at present.)

Name . . . . Date .

> For how much money, paid in cash, would you do or suffer the following? Write the amounts on the dotted line. You must suppose that the money can be spent on yourself only and that whatever you buy with it is destroyed when you die. You cannot use any of it for your friends, relatives, or charity[2]

---

*Received in the Editorial Office on February 3, 1937

[1] The observations reported in this article are one item in a project supported by a grant from the Carnegie Corporation

[2] The restrictions of the last two sentences were made in order to keep the calculus of pains, deprivations and frustrations free from a calculus of benefits to others than oneself I doubt whether this result was fully attained and think that the same experiment with no limitations on the use of the payments would be even more instructive

What happens in the case of most persons in responding to these 51 questions is that certain of the deprivations, etc, seem unobjectionable and are estimated at zero or some nominal small sum, certain others are regarded as utterly intolerable, and evoke "No sum large enough," "There is

1 Have one upper front tooth pulled out [$5000, $4500]
2. Have all your teeth pulled out [$1,000,000, $750,000]
3 Have one ear cut off [No sum, $1,500,000]
. .4 Have your left arm cut off at the elbow (right arm if you prefer) [No sum, $2,500,000]
5 Have a little finger of one hand cut off [$75,000; $200,000]
. 6 Have the little toe of one foot cut off [$10,000, $57,000]
. 7 Become entirely bald [$750,000, $75,000]]
. . .8 Have all the hair of your eyebrows fall out [$100,000, $25,000]
. . 9. Have one leg cut off at the knee [No sum; $40,000,000]
. 10. Have both legs paralyzed [No sum; $40,000,000]
11. Have small-pox, recover perfectly, except for about 20 large pock-marks on your cheeks and forehead. [No sum, $1,000,000]
. .12 Become totally deaf. [No sum, $100,000,000]
. .13 Become totally blind [No sum, no sum]
.14 Become unable to chew, so that you can eat only liquid food [No sum; $10,000,000]
. . .15 Become unable to speak, so that you can communicate only by writing, signs, etc [No sum; $15,000,000]
. .16 Become unable to taste. [$1,000,000; $5,000,000]
. 17. Become unable to smell. [$300,000, $150,000]
. 18 Require 25 per cent more sleep than now to produce the same degree of rest and recuperation [$100,000, $37,500]
. . .19 Fall into a trance or hibernating state throughout October of every year [$300,000, $325,000]
. 20 Fall into a trance or hibernating state throughout March of every year. [$200,000, $400,000]
. . . 21. Be temporarily insane throughout July of every year (manic-depression insanity, bad enough so that you would have to be put in an insane asylum, but with no permanent ill effects) [No sum; $2,500,000]
.22 Same as 21, but for two entire years now,[8] with no recurrence ever again [No sum; $5,000,000]
. . 23 Have to live all the rest of your life outside of U S A. [$200,000, $150,000]
. . .24 Have to live all the rest of your life in Iceland. [No sum, $1,000,000]
. . 25. Have to live all the rest of your life in Japan [$1,000,000; $500,000]
.26. Have to live all the rest of your life in Russia [$1,000,000, $150,000]

---

not enough money," "$1,000,000^{100}," and the like; certain others are regarded as not so utterly intolerable and rated at 100 million, 10 million, 5 million or other large sums Some of the others are given amounts which represent what the person thinks would induce him to do or suffer the thing in question and which therefore correspond roughly to their relative demerits from his standpoint, but many are given amounts which seem to fit the scale he has established by his ratings up to that point, without close consideration of each as the stimulus to bargaining.

[8] By my error the 21 was printed as 20, but the nature of the text led many of the subjects to treat it as 21 The valuations of this item are thus ambiguous.

27 Have to live all the rest of your life in Nicaragua [$1,000,000, $500,000]
28. Have to live all the rest of your life in New York City [$50,000; $25,000]
29 Have to live all the rest of your life in Boston, Mass. [$100,000, $50,000]
30 Have to live all the rest of your life on a farm in Kansas, ten miles from any town [$1,000,000, $300,000]
31 Have to live all the rest of your life shut up in an apartment in New York City You can have friends come to see you there, but cannot go out of the apartment [No sum; $60,000,000]
32. Eat a dead beetle one inch long [$5,000; $5,000]
33 Eat a live beetle one inch long [$25,000, $50,000]
34 Eat a dead earthworm 6 inches long [$5,000; $25,000]
35. Eat a live earthworm 6 inches long. [$10,000, $100,000]
36. Eat a quarter of a pound of cooked human flesh (supposing that nobody but the person who pays you to do so will ever know it). [$1,000,000; $100,000]
37 Eat a quarter of a pound of cooked human flesh (supposing that the fact that you do so will appear next day on the front page of all the New York papers). [No sum, $7,500,000]
38. Drink enough to become thoroughly intoxicated. [$100, $50]
39 Choke a stray cat to death. [$10,000; $10,000]
40 Let a harmless snake 5 feet long coil itself round your arms and head. [$500, $100]
41 Attend Sunday morning service in St. Patrick's Cathedral, and in the middle of the service run down the aisle to the altar, yelling "The time has come, the time has come" as loud as you can until you are dragged out. [$100,000, $1,000]
42 Take a sharp knife and cut a pig's throat. [$1,000, $500]
43. Walk down Broadway from 120th Street to 80th Street at noon wearing evening clothes and no hat [$200; $100]
44 Spit on a picture of Charles Darwin. [$20, $10]
45 Spit on a picture of George Washington [$50; $10]
46 Spit on a picture of your mother [$10,000, $25,000]
47 Spit on a crucifix [$300, $5]
48 Suffer for an hour pain as severe as the worst headache or toothache you have ever had [$500, $250]
49 Have nothing to eat but bread, milk, spinach and yeast cakes for a year [$10,000, $25,000]
50 Go without sugar in all forms (including cake, etc), tea, coffee, *tobacco, and alcoholic drink, for a year* [$1,750, $2,000]
51 Lose all hope of life after death [$6,500, $50]

I shall discuss first the reports made in April, 1934, by a group who had been employed for three months by the *C W. A* as subjects in experiments in adult learning, and who were accustomed to taking all sorts of tests and answering all sorts of questions. They consisted of males under 30, females under 30, males over 40 and females over 40, and covered a wide range of intellectual ability and amount of education, though the majority were college graduates of much above average intelligence

1 Have one upper front tooth pulled out [$5000, $4500]
2 Have all your teeth pulled out [$1,000,000; $750,000]
3 Have one ear cut off [No sum, $1,500,000]
4. Have your left arm cut off at the elbow (right arm if you prefer) [No sum; $2,500,000]
5 Have a little finger of one hand cut off. [$75,000, $200,000]
6. Have the little toe of one foot cut off [$10,000; $57,000]
7. Become entirely bald [$750,000, $75,000]]
8. Have all the hair of your eyebrows fall out. [$100,000, $25,000]
9 Have one leg cut off at the knee [No sum, $40,000,000]
10 Have both legs paralyzed. [No sum, $40,000,000]
11 Have small-pox, recover perfectly, except for about 20 large pockmarks on your cheeks and forehead [No sum, $1,000,000]
12 Become totally deaf [No sum, $100,000,000]
13 Become totally blind [No sum, no sum]
14. Become unable to chew, so that you can eat only liquid food [No sum, $10,000,000]
15 Become unable to speak, so that you can communicate only by writing, signs, etc [No sum, $15,000,000]
16 Become unable to taste. [$1,000,000, $5,000,000]
17 Become unable to smell. [$300,000; $150,000]
18. Require 25 per cent more sleep than now to produce the same degree of rest and recuperation [$100,000; $37,500]
19. Fall into a trance or hibernating state throughout October of every year [$300,000, $325,000]
20 Fall into a trance or hibernating state throughout March of every year. [$200,000, $400,000]
21 Be temporarily insane throughout July of every year (manic-depression insanity, bad enough so that you would have to be put in an insane asylum, but with no permanent ill effects) [No sum; $2,500,000]
22. Same as 21, but for two entire years now,[3] with no recurrence ever again. [No sum, $5,000,000]
23 Have to live all the rest of your life outside of U S A. [$200,000, $150,000]
24. Have to live all the rest of your life in Iceland. [No sum, $1,000,000]
25. Have to live all the rest of your life in Japan [$1,000,000, $500,000]
26. Have to live all the rest of your life in Russia [$1,000,000; $150,000]

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not enough money," "$1,000,000^{100}," and the like; certain others are regarded as not so utterly intolerable and rated at 100 million, 10 million, 5 million or other large sums Some of the others are given amounts which represent what the person thinks would induce him to do or suffer the thing in question and which therefore correspond roughly to their relative demerits from his standpoint, but many are given amounts which seem to fit the scale he has established by his ratings up to that point, without close consideration of each as the stimulus to bargaining.

[3] By my error the 21 was printed as 20, but the nature of the text led many of the subjects to treat it as 21 The valuations of this item are thus ambiguous

27. *Have to live all the rest of your life in Nicaragua* [*$1,000,000*, $500,000]
28. Have to live all the rest of your life in New York City [$50,000; $25,000]
29 Have to live all the rest of your life in Boston, Mass. [$100,000; $50,000]
30 Have to live all the rest of your life on a farm in Kansas, ten miles from any town [$1,000,000, $300,000]
31 Have to live all the rest of your life shut up in an apartment in New York City You can have friends come to see you there, but cannot go out of the apartment. [No sum, $60,000,000]
32. Eat a dead beetle one inch long [$5,000, $5,000]
33. Eat a live beetle one inch long. [$25,000, $50,000]
34. Eat a dead earthworm 6 inches long [$5,000; $25,000]
35. Eat a live earthworm 6 inches long. [$10,000, $100,000]
36 Eat a quarter of a pound of cooked human flesh (supposing that nobody but the person who pays you to do so will ever know it). [$1,000,000; $100,000]
37 Eat a quarter of a pound of cooked human flesh (supposing that the fact that you do so will appear next day on the front page of all the New York papers) [No sum; $7,500,000]
38 Drink enough to become thoroughly intoxicated. [$100, $50]
39 Choke a stray cat to death. [$10,000, $10,000]
40 Let a harmless snake 5 feet long coil itself round your arms and head [$500, $100]
41 Attend Sunday morning service in St Patrick's Cathedral, and in the middle of the service run down the aisle to the altar, yelling "The time has come, the time has come" as loud as you can until you are dragged out [$100,000; $1,000]
42 Take a sharp knife and cut a pig's throat [$1,000; $500]
43 *Walk down Broadway from 120th Street to 80th Street at noon* wearing evening clothes and no hat [$200; $100]
44. Spit on a picture of Charles Darwin. [$20, $10]
45. Spit on a picture of George Washington [$50, $10]
46 Spit on a picture of your mother. [$10,000, $25,000]
47 Spit on a crucifix [$300, $5]
48 Suffer for an hour pain as severe as the worst headache or toothache you have ever had [$500, $250]
49. Have nothing to eat but bread, milk, spinach and yeast cakes for a year [$10,000, $25,000]
50 Go without sugar in all forms (including cake, etc.), tea, coffee, tobacco, and alcoholic drink, for a year [$1,750, $2,000]
51 Lose all hope of life after death [$6,500, $50]

I shall discuss first the reports made in April, 1934, by a group who had been employed for three months by the *C. W. A.* as subjects in experiments in adult learning, and who were accustomed to taking all sorts of tests and answering all sorts of questions They consisted of males under 30, females under 30, males over 40 and females over 40, and covered a wide range of intellectual ability and amount of education, though the majority were college graduates of much above average intelligence

In spite of their wide experience as subjects in psychological tests and experiments, some were so overcome by the novel task that they would make no estimates or only for a very few of the 51 injuries, deprivations, repulsive acts, etc. Some reported that no amount of money would induce them to do or suffer any of them. These reports, though apparently absurd, may be sincere

The most striking fact about the reports in general is the absurd magnitude of the bids. The loss of one little toe is put as priceless by one-fifth of the group, and at from $50,000 to $10,000,000 by another fifth. The median valuation is near $25,000! An hour of the severest pain known to the person is put at $250 or over by half of the young men, and at $500 or over by half of the young women Half of the group required over $50,000 for eating a beetle or worm (average for living and dead). Only a fifth make bids under $1000. The impairment of physical attractiveness by the loss of one ear and both eyebrows, total baldness, and the presence of 20 pock marks totals a million dollars for over three-fifths of the group The deprivation from sugar for a year is put at $1000 or more by three fourths of the group. Similar utterly unreasonable estimates appear throughout The median estimates for 19 men and 20 women under 30 appear as the second of the two numbers printed after each item.

Why did these persons put these absurdly high valuations upon suffering these imagined injuries, deformities, degradations, etc.? The first possibility to consider is that many of them did not take up any of the suppositions seriously, that their estimates were given carelessly and represented only a general pronounced negative attitude. There is this much truth in this supposition: namely, that (*a*) voluntary acceptance of some of the suggested calamities is to many individuals so utterly intolerable that they cannot bring their minds to consider it, and that (*b*) this attitude occasionally transfers to act and sufferings which, had they been presented alone, would have been rated much more reasonably The first fact is important It illustrates a strong tendency in mankind to refuse to face personal calamities in imaginative bargaining in any straightforward, intellectual way, other than to utterly eschew them.

There were two flippant reports and probably some careless ones, but the reports of persons whose characters guarantee their cooperation and sincerity are not observably different from those who might be suspected of carelessness. Moreover, as will be shown later, reports from members of the Psychology Club of Teachers College show the same general facts as these

There is also internal evidence that most of the reports are genuine expressions of opinion. For example, the requirements to balance personal disfigurement of 3, 7, 8, and 11 are higher for young women than for young men and are very much lower for old men than for the others. The requirements to balance eating beetles and worms are enormously higher for the women than for the men The payment for spitting on a crucifix ranges from 0 to infinity. The relative payments required are reasonable within any group of comparable items (such as 1, 2, 3, 4, 5, 6, 9, and 10; or 12, 13, 16 and 17, or 24, 25, 27, and 29) There is little or no concealment of unorthodox traits, for example, a quarter of the group reported less than $10 for their hope of immortality It may be objected that all the bids of over a half a million are proof of carelessness, since the assumption was to be that the money could be spent only on one's self, and since for that purpose an annuity of $25,000 or more would be as good as any larger amount But a neglect of this fact in the process of making comparative estimates is not a proof of general carelessness We must, I think, accept the great majority of the absurdly high bids as genuine expressions of the persons' attitudes.

How well these attitudes prophecy what the persons would do if real money offers were made can only be surmised. Doubtless there would be many changes, mostly downward, but I believe that essentially uneconomical refusals and requirements would remain for many items It may seem incredible that any persons needing money as much as these recipients of public funds did would not gladly sacrifice one toe for $5000, or endure an hour of pain for $100, or eat a beetle for $500, or cut a pig's throat for $100, or eat ¼ pound of cooked human flesh secretly for $10,000 It is, however, credible to the writer because of two facts. First, a person may know that a certain course of conduct is to his advantage and ardently wish to do it, but be prevented from doing so by an inner compulsion Second, the essence of the transaction may not be the temporary nausea or misery, but the permanent remorse, loss of self-respect, or other torment These two facts are of general importance The obsessional power of certain tabus, notions, habits, etc, is widespread Just as certain persons simply cannot take the wiggling worm and chew it up, so certain workers simply cannot change their trade, certain farmers cannot give up their profitless farms and work under orders in a factory, certain artists cannot do as they are told. They may wish to do so, but their natures must be changed in radical ways to make it possible. The force of self-approval is enormous because it acts incessantly and is inescapable. Some psychiatrists believe that it is literally true that persons will become insane in order to retain it The approval of others operates in large measure by making a person content with himself The serf could endure his lot in large measure because he could respect himself in his status as the lord could in his. We are all prone to blame luck or favoritism or the government rather than our own ineptness Whatever its supernatural powers may be, religion as a natural phenomenon has had much of its power because it could put man at peace with himself

A third important fact is suggested by the high prices set upon the various acts and sufferings: namely, the undervaluation of insurance against hunger, cold, and exposure. Among the items were some which would (at least in ninety-nine persons out of a hundred) entail no conflict with any obsession and no loss of social approval or self approval Any penniless person who had a realizing fear of physical miseries would presumably gladly buy insurance against them at the cost of a finger and toe, or of being unable to smell, or of eating only bread, milk, spinach and yeast cakes for a year. But even for the last we have over a third of the persons demanding $50,000 or more! The realizing fear was probably absent in many of the group. They probably had never had any protracted experience of hunger and cold, and took it for granted that somehow the world would feed and clothe them as it always had done And this is true of a very large proportion of the population of the United States Many of us are so used to food, clothes, and shelter that we do not thank either God or the social order for them, nor even consider that the provision might fail.

To the extent that the reports represent genuine attitudes toward reality, we may use them as indications of real motives For example, items 3, 7, 8 and 11 (*have one ear cut off, become entirely bald; have all the hair of your eyebrows fall out; have small-pox and* *recover perfectly, except for about 20 large pockmarks on your cheeks and forehead*) concern personal appearance primarily. Items 14, 16, 17, 48, 49, and 50 (*become unable to chew, so that you can eat only liquid food, become unable to taste, become unable to smell, suffer for one hour pain as severe as the worst headache or toothache you have ever had, have nothing to eat but bread, milk, spinach and yeast cakes for a year, go without sugar in all forms—including cake, etc.—, tea, coffee, tobacco, and alcoholic drink for a year*) concern sheer discomfort primarily. Item 18 (*require 25 per cent more sleep than now to produce the same degree of rest and recuperation*) concerns loss of time. The difference between the obnoxiousness of 31 and 28 (*have to live all the rest of your life shut up in an apartment in New York City. You can have friends come to see you there, but you cannot go out of the apartment; have to live all the rest of your life in New York City*) is an indication of the dislike of confinement.

If the reports do not represent what the persons would do if real money offers were made, they at least represent attitudes of the persons toward imagined offers. The relative magnitudes will be instructive in either case.

I therefore report in Table 1 the median estimates and the lowest estimates for 19 young men and 20 young women for certain items and combinations of items. The highest estimates are ∞ or some enormous number in all cases save 43, which one woman offers to endure for $100,000

The reader may draw his own conclusions from the facts of this table He should note the ultra-realism which demands a thousand times as much for suffering an hour of pain as for spitting on Darwin's or Washington's picture, and eighty times as much for baldness or pock marks (in women), as for spitting on the picture of one's mother He should note also the relative tolerance of disgracing oneself, and the great aversion to minor and almost harmless mutilations of one's body and limitations to one's freedom.

The same questions were asked in November, 1934, of 58 students and teachers of psychology, mostly between 25 and 35 years old, and about equally divided between men and women The answers were written anonymously About five-sixths of the group were students, and it may safely be assumed that three-fourths of the group had no present or future income beyond earnings Very few, however,

TABLE 1

ESTIMATES OF THE AMOUNTS OF MONEY WHICH WOULD INDUCE THE PERSONS IN QUESTION TO DO OR SUFFER THE THING IN QUESTION

		Young C W. A workers				Graduate students and teachers median
		Median		Lowest		
		M	F	M	F	
1	Average of 44 and 45 (spit on pictures of Darwin and Washington)	10	10	0	0	40
2	38 (become thoroughly intoxicated)	25	98	0	0	100
3	43 (walk 2 miles on Broadway in evening clothes at noon)	125	75	0	5	100
4	40 (let snake coil around arms and head)	100	400	0	10	500
5	41 (run yelling down aisle of cathedral during Sunday service)	1,250	1,000	20	15	10,000
6	Average of 39 and 42 (choke a cat, cut a pig's throat).	1,250	105,000	2	25	7,500
7.	18 (lose time by need for 25 per cent more sleep)	25,000	2,500	20	500	100,000
8	Average of 48, 49 and 50 (1 hour pain; year on bread, milk, etc , year without sugar and alcoholic drinks).	33,000	10,700	100	233	3,000
9	46 (spit on a picture of one's mother)	25,000	22,500	1	5	5,000
10.	Average of 32, 33, 34, and 35 (eat dead beetle, live beetle, dead earthworm, and live earthworm)	12,500	62,500	4	2,200	5,000
11	Average of 3, 7, 8, and 11 (lose an ear, become bald, lose hair of eyebrows, acquire 20 pock marks)	31,000	1¾ mill	1,000	7,600	1 mill
12	Average of 28 and 29 (restriction of habitat to New York or to Boston).	40,000	30,000	0	0	75,000
13	36 (eat human flesh secretly)	50,000	100,000	40	1,000	1 mill
14	Average of 5 and 6 (lose little finger, lose toe)	200,000	75,000	500	2,800	300,000
15	Average of 19 and 20 (fall into a trance for a month every year)	1 mill	100,000	2,500	750	200,000
16.	Average of 23 to 30 (restriction of habitat to outside U S A, Iceland, Japan, Russia, Nicaragua, N Y City, Boston, Kansas, farm)	1½ mill	500,000	5,500	13,300	500,000
17	37 minus 36 (eat human flesh publicly instead of secretly)	6½ mill	325,000	0	0	?
18	21 (be insane one month every year)	5 mill	1½ mill	20,000	35,000	∞
19	37 (eat human flesh and have the fact widely known)	10 mill	1 mill	250	5,000	∞
20	31 minus 28 (confinement indoors)	2 mill	100 mill	100	0	—500,000
21	Average of 14, 16, and 17 (become unable to chew, taste, smell)	6 mill	41,000	12,000	12,000	1½ mill.
22	Average of 2, 4, and 9 (lose all teeth, left arm, one leg)	36 mill	6 mill	1,900	26,000	∞
23	12 (lose hearing).		52 mill	40,000	10,000	∞
24	15 (lose speech)		100 mill	75,000	75,000	1 mill
25	13 (lose vision)		100 mill	100,[illegible]	100 [illegible]	∞

were destitute or receiving public relief as all in the other group were

All the general characteristics of the returns are the same for this group as for the other They too make extravagant demands, expressing the aversions which they feel rather than reasonable balancing of the pain, deprivation, or frustration against what money can buy They too suffer from inner compulsions They too probably undervalue security from hunger, cold, and exposure.

The medians for various items are presented in the last column of Table 1 They are of the same general magnitude as those for the other group, and hold much the same relative positions. The chief differences are:

1. Greater aversion to spitting on pictures of Darwin and Washington (40 to 10)

5. Greater aversion to causing a disgraceful disturbance in church (10,000 to 1,125).

7. Greater aversion to losing time by sleep (100,000 to 14,000)

8 Less aversion to sheer pain and discomfort (3,000 to 22,000)

9. Less aversion to spitting on a picture of one's mother (5,000 to 24,000)

10. Less aversion to eating the worm or beetle (5,000 to 3,800)

13. Greater aversion to eating human flesh secretly (1,000,000 to 75,000).

No one of these by itself has much reliability because of the great variation within both groups. If they agree in supporting some one explanation of themselves, it would be worth consideration, but they do not. Though 8 and 10 suggest greater reasonableness in the psychology group, 13 and 14 oppose this. Though 1 and 5 suggest greater sensitiveness, or greater conventionality, 9 and 3 oppose this

On the whole, it is safest to treat the differences between the two groups as unimportant

As has been suggested earlier in this report, the imagined valuations expressed by these show certain features of real valuations, especially a tendency of educated persons to order their preferences in terms of money price limited by the conviction that certain states of affairs are so undesirable that no amount of money can compensate for them.

The sciences of man are tempted to describe and measure the causes of conduct by some simple and logical scheme Bentham's is the most famous of such Lewin's is the latest. Any scheme must I think take account of certain positive wants, desires, drives, impulses or preferences *pro* and of certain negative wants, aversions, or preferences *con* which are infinitely strong in the sense that the person in question in the situation in question does not treat the status or tendency in question as a quantity to be weighed in comparison with others, but as something utterly desirable or intolerable To a thirsty infant a drink is worth everything in the sense that he craves it wholeheartedly and irrespective of all else Even after many years of training in quantifying the force of all sorts of desirable and undesirables by thinking of their consequences and of other alternative possibilities, much obsessional activity remains. A hedonic calculus, or any other calculus of motivation, must reckon with it

Students of valuation disagree about the extent to which values are commensurate, so that for any given person in any given situation the relative magnitudes of the values to him of, say, a feeling of safety, a compliment, the beautiful sunset, a long-deferred smoke, and the cessation of a toothache can be computed. A safe step toward a solution is to realize that if the person does in fact prefer *A* to *B*, then he has set *A* as greater in value than *B* no matter how disparate they may be.

Our experiment illustrates both the wide range of such valuation and some of its difficulties, in the case of negative values. Using money as their measure, some persons can in thought, and probably could in reality, readily put our 51 mutilations, pains, deprivations, degradations and frustrations into an order of preference. Some persons rebel against the task But their rebellion occurred not in proportion as the undesirables are unlike but in proportion as they are great. The more convincing illustrations given in arguments against commensurability are likely to be cases of great beauty, great elevation of spirit, great bodily pain, great shame, and so on. The very man who insists that one scale of value for literary delights and smoking is impossible will admit that he preferred to use sixpence for Punch rather than cigarettes, or vice versa. It may be hard for him to decide whether he prefers to give up all reading for two months or to give up all smoking for ten years But that may not be because of the incomparability of the satisfactions, but because both are intolerable.

The Intercorrelations of the Valuations of Certain Sorts of Items

If we examine the values put upon the items (1, 2, 7, 8, and 11) affecting personal appearance chiefly, we can put 58 of the psychology-club group into a probable order for the magnitude of their demands, though the difficulty of combining infinity ratings with the others makes it only a probable order. The same can be done for 14, 16 and 17 (*the discomforts of being unable to chew, taste and smell*), for 48, 49 and 50 (*discomforts of pain, restrictive diet, and deprivation from sugar, tea, coffee, tobacco and alcohol*); for 18, 19, 20 and 22 (*loss of time and more or less disrepute*), for 23 to 30 (*restrictions on habitat*), and for the more or less revolting experiences of 32 33, 34, 35, 39, 40 and 42 (*eating beetles and worms, choking cats, etc.*)

The mutilations and serious deprivations have too many infinite demands to justify rankings in respect of them

TABLE 2
Intercorrelations of Groups of Values*

	1	2	3	4	5	6	Sum of 1-6
1 (Appearance)	Psych	55	40	.55	53	31	.75
	M.	.63	72	73	34	.60	91
	F	.64	—09	60	13	36	81
2 (Discomfort A)	Psych		49	43	33	46	.74
	M		.31	65	.45	60	.77
	F.		—19	.65	.16	.08	67
3 (Discomfort B)	Psych			.33	.37	42	.69
	M.			39	.20	60	74
	F.			—39	—04	—23	—.01
4 (Time and disrepute)	Psych				.58	54	79
	M.				14	28	.73
	F.				43	.32	84
5 (Restricted habitat)	Psych.					.23	.69
	M					19	45
	F					15	50
6 (Revolting experiences)	Psych						69
	M						76
	F						.42

*The standard errors of the intercorrelations run from 09 to .12 for those for the Psychology Club, and from 11 to 20 for those for unemployed males or females

I have grave doubts concerning the amount of correspondence between these ranks and the ranks that would be obtained if some eccentric millionaire should make offers of real money to the persons in question. They are, however, probably as significant as any that can be obtained by any such expressions of opinion. So I have computed the intercorrelations, and the partial correlations when the persons are roughly equalized in respect of their general degree of aversion (by summing the six ranks for each).

The intercorrelations of the six composites are as shown in Table 2. Along with them are shown the same intercorrelations for 20 young unemployed males and 19 young unemployed females, but these should have little weight.

With the exception of composite 3 for the unemployed females, all the correlations are positive We may conjecture that in a genuine experiment individuals would still differ, though perhaps not to the same extent, in the general strength of their aversions There is no sure constellation of these reported aversions, though 1, 2 and 4 seem more closely linked than can be explained by the general tendency to feel strong aversions, or the general tendency to use too high a scale, or both.

TABLE 3

INTERCORRELATIONS OF GROUPS OF VALUES, AFTER EQUALIZATION IN RESPECT TO THE SUM OF 1-6

		2	3	4	5	6
1 (Appearance)	Psych.	—01	—02	—10	03	—43
	M.	—26	.18	.22	—19	—34
	F.	35	—02	—25	—53	.04
2 (Discomfort A)	Psych		—.04	—37	—.37	—02
	M.		—61	21	.22	04
	F.		—27	22	—.27	—30
3 (Discomfort B)	Psych.			—48	—20	—11
	M			—33	—22	09
	F			—74	—05	—26
4 (Time and disrepute)	Psych.				08	—01
	M.				—31	—62
	F				02	—07
5 (Restricted habitat)	Psych.					—47
	M.					—26
	F					—08
6 (Revolting experiences)						

The partial correlations of Table 3 report the intercorrelations which would be found among persons identical in their total amount of expressed aversion, and consequently must be negative on the average. They do not oppose our conjectures. Weighting them as 3, 1 and 1 (without troubling to make zeta transformations), 1, 2 and 4 show partials of .01, —.07, and —.16. At the other extreme are 3 with 4 and 5 with 6, having partials of —.50 and —.35. The median of these weighted partial *r*'s is —.14.

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FAVORABLE AND UNFAVORABLE ATTITUDES TOWARD PREGNANCY IN PRIMIPARAE*

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MARIAN A DESPRES

I ORIENTATION

In the last decade there has been a decided shift among clinicians and teachers dealing with children's problems from emphasis on the child, to emphasis on the parent-child relationship The mother-child relationship especially has become the focus of attention Therefore it is of interest to know what the mother's reactions are, uncomplicated by the sex and personality of the child, and what factors influence this attitude most strongly The present study of the attitudes of expectant mothers was undertaken with this problem in view.

The writings of David Levy (6, 7) contain one of the most fertile hypotheses on factors influencing the maternal attitude toward the existing child His suggestion that the mother's early emotional impoverishment, too much early responsibility, and unsatisfactory marital adjustment, among other things, affect her later attitude, was adopted for this study of the factors influencing the woman's attitude toward her expected child Other factors that were thought to be of potential importance for the attitude of the primipara, and so were included for consideration in this study were: (*a*) the subject's ordinal position in her family, (*b*) the number and sex of her siblings, (*c*) the age at which she obtained her sex information, and the sources from which it came, (*d*) her feeling of economic security during marriage and pregnancy, (*e*) her neurotic tendency, and lastly, (*f*) the physiological manifestations of normal development and pregnancy.

II METHOD AND PROCEDURE

Criterion

One important purpose of this investigation was to determine

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whether entities as amorphous as attitudes toward pregnancy and influences contributing to it could be studied by an objective method

Previous studies of the mother-child relationship had used as criteria the psychiatrist's or social worker's opinion of the mother's attitude This is extremely subjective, demands either a full case history or a long time observation, and judges the mother in terms of her actual behavior toward the child. Attempts have been made by Laws (6) and by Fitz-Simons (2) to find objective standards, but their methods also demand a long experience with the actual mother-child relationship In the present study, the writer could not use any criterion depending on the already existing relationship, and did not want to use any criterion that would take a long time, or that would depend on a personal evaluation. Therefore, it was decided to use as criterion the total score on a number of questions directly concerning the woman's feelings toward pregnancy and the manner in which it affected her daily life

The Questionnaire

A questionnaire was also decided on as the best method available for obtaining the type of information desired The answers to the questions are not taken as facts, but as events that have been shaped in the subject's memory by her needs and desires, especially in the light of her present experience. The emotional coloring she gives to past events is more important for this study than their factual accuracy. Therefore, the answers are taken as they are given, but they are not to be understood as literal representations of the past.

The questionnaire contained sections on descriptive data, sex education, physiological functions, childhood, marriage, and pregnancy This last section served as criterion. Each question was made as specific and simple as possible, and was answerable on a graphic scale

At the end of the questionnaire was a short version of the Thurstone Personality Schedule as revised by R. R. Willoughby (10).

Statistical Treatment

The questions were scored by a stencil that divided the line into five equal parts

After experimenting with the available correlational methods, it was found they were not satisfactory, so it was decided to use the method of group differences The groups to be compared were the most favorable and least favorable quarters of the whole group examined, chosen on the basis of their scores on the criterion section. Separate items were scored in both these groups and when the obtained difference between the two means for any one item was greater than three times its probable error, it was considered significant enough to be given further discussion

In some cases the answers to the descriptive questions were given in terms of two categories instead of on a scale For these, the probable error of proportion (5) was used and the difference divided by its probable error handled in the same way. The probability that these differences were real could then be compared for all types of data

The reliability of the separate items of the questionnaire was determined by using the coefficient of contingency The reliability of the total score on each section was measured by the Pearsonian coefficient of correlation

Procedure with the Individual Subject

The subjects were seen in the regular pre-natal clinics of the Lying-In and Michael Reese Hospitals in Chicago The questionnaire was filled out in a private interview with the writer while the subject was making her routine clinic visit A uniform approach was made to all subjects and uniform instructions were given The patient understood that filling out the questionnaire was voluntary There were almost no refusals

Groups to Whom Questionnaire Was Given

The questionnaire in rough form was first given to several preliminary groups to see if results could be obtained by this method, to see whether the subject responded best to a verbal or to a graphic scale, and to see which questions were phrased so as to be easily understood by the group for whom they were intended. After going over these papers carefully, omitting words and questions that were not clear or easy for the subjects to understand, the questionnaire was thoroughly revised and put in final form

This form of the questionnaire was then given to 100 unselected primiparae After this group was completed, the questionnaire was repeated with 25 of the same subjects in order to test the reliability of the questionnaire itself It was not necessary to repeat the giving of the Personality schedule since its reliability is already given by Willoughby (11).

While 153 women who were approached cooperated entirely, four others approached in the same manner were unwilling to answer the questionnaire, giving as reasons that they would rather not, they couldn't remember their childhood, or that they were afraid they would lose their place in line to see the doctor

Description of Subjects

Eighty-six per cent of the final group were born in the United States. The average age was 23 17 Forty-one were Protestant, 38 were Catholic, and 12 were Jewish Nine had other religions or none. The average school attendance for the group was 9 73 years. The subjects had worked an average of 4 80 years, and the present yearly income was between $540 and $1,500. Eight subjects were dependent or on relief, and three had incomes between $1,500 and $2,400.

III. Results

Reliability

The reliability of the separate questions as measured by C ranged in magnitude from 48 to 85. The mean was at 75 40.

The reliability of the total score of each section of the questionnaire was determined by the Pearsonian coefficient of correlation The reliabilities of the sections were:

I Childhood +.90±.01.
II Marriage + 81±.02.
III. Pregnancy + 86±.02 (Criterion).

Validity

The relationships and facts by which the criterion is validated are as follows:

1. The criterion asks direct questions concerning the attitude being measured.

2. The criterion shows large group differences between the first and fourth quartiles of a fairly homogeneous group.

3. The internal consistency of the criterion section is high The agreement between it and all the items of which it is composed indicates that the items, though different, are closely related.

TABLES 1*A* AND 1*B*

COMPARISON OF FAVORABLE AND UNFAVORABLE PRIMIPARAE IN RESPECT TO DESCRIPTIVE DATA

Data Sheet 1

1*A* (PE of the difference)

Item	M_1	M_2	PE_D	$\frac{D}{PE_D}$
No brothers	2 00	1 00	27	—3 74
Time husb employed	4 12	1 92	69	—3 19
No sibs	3 92	2 76	.42	—2 74
Age at marriage	21 12	19 92	46	—2 63
Present age	23 20	21 52	68	—2 47
Clinic age	51 60	43 60	3 29	—2 43
Yrs bus training	4 62	1 92	1 35	—2 00
Yrs husb's schooling	11 17	10 38	.43	—1 82
Yrs wife's schooling	9.96	9 48	35	—1.36
Yrs married	1.95	1 60	30	—1 16
Yrs working	4 80	4 12	67	—1 01
Husb's age	27 16	26 44	92	— .78
No sisters	1 92	1 76	.27	— .59
Liked work	1 68	1 64	15	— .27
Month gestation	7.08	7 08		

1*B* (PE of the proportion)

Item	P_1	P_2	PE_D	$\frac{D}{PE_D}$
Husb employed	1 00	.76	06	—4.21
Only child	00	16	05	3.26
Jewish	00	16	05	3 26
Intermediate child	56	32	09	—2.66
Protestant	60	36	09	—2.66
Catholic	28	44	09	1 77
Oldest child	20	32	08	1 44
Husb emp'd full time	80	75	08	— 59
Youngest child	.24	.20	08	— .50
Own parents until 16	80	76	08	— 50
Born outside U S	10	10		

M_1 Mean score of the 25 per cent of the group most favorable toward pregnancy, hereafter called Group I Items on the questionnaire are scored from 1 to 5, 1 being the most favorable reply

M_2: Mean score of the most unfavorable 25 per cent, hereafter called Group II

PE_D Probable error of the difference between the means

$\frac{D}{PE_D}$ From this ratio is calculated the probability that the difference is a real one (see H Garrett, *Statistics in Psychology and Education.* New York. Longmans, Green and Co, 1931 Table XV, p 135) A minus sign before this ratio indicates that M_1 or P_1 is larger than M_2 or P_2

P_1 and P_2: This number is the proportion of each group which falls within the corresponding classification listed in the column headed "Item"

Each item is scored in terms of its natural unit except "liked work" which was arbitrarily scored from 1 to 3, 3 indicating the strongest liking for work

Apparent mathematical discrepancies in this and the following tables are due to the fact that all calculations were made with four place numbers which were then reduced to two places In no case does this alter the final probability

TABLE 2*A*

COMPARISON OF FAVORABLE AND UNFAVORABLE PRIMIPARAE IN RESPECT TO SEX EDUCATION AND PHYSIOLOGICAL DATA

Data Sheet 2
(PE of the difference)

Item	M_1	M_2	PE_D	$\frac{D}{PE_D}$
Age of learning re sex	16 09	13 83	.58	—5.90
Age of learning re birth	13 62	12 13	55	—2 70
Age of learning re menst	11 89	11 76	37	— 35
Menstruation				
Pain	1 00	1 60	22	2 74
Age at onset	13 04	13 36	31	1 04
Duration in days	4 28	4 44	25	48
Interval	27.64	27 95	1 02	30
Nausea				
Duration in weeks	4 68	8 00	1 08	3 09
Severity	1 04	1 64	21	2 85
Daily frequency	1 32	1 52	20	98
Week it began	5 13	5 19	62	10

4 The results agree in many respects with those of analogous studies on the mother-child relationship.

5. The items of Sections I and II that show most agreement with the criterion build up a consistent and logical picture of factors associated with a favorable or unfavorable attitude toward pregnancy.

6 The range of scores on the criterion was 8 to 39 out of a possible 8 to 40. This range and the fairly normal distribution of scores indicate that lack of frankness in the subjects, if any, did not seriously affect results.

Relation of Neurotic Tendency

A question closely related to the validity of the investigation is. how far are the items that are related to an unfavorable attitude toward pregnancy chiefly the expression of a general neurotic tendency The results of measuring the Inventory against the criterion follow:

M_1	M_2	PE_D	$\frac{D}{PE_D}$
19 56	31 16	2.75	4 22

TABLE 2B

COMPARISON OF FAVORABLE AND UNFAVORABLE PRIMIPARAE IN RESPECT TO SEX EDUCATION AND PHYSIOLOGICAL DATA

Data Sheet 2
(PE of the proportion)

Item	P_1	P_2	PE_D	$\frac{D}{PE_D}$
Baby planned for	80	.37	08	—5 18
Complaints	36	64	09	3 08
Used contraceptives	12	36	08	3 08
During Menst				
Crabby	.44	67	.09	2.47
Has pains	52	68	.09	1.76
Depressed	24	35	09	1 25
Tired	44	54	10	1.05
During pregnancy				
Vomited	44	.80	09	4 19
Nauseated	52	.80	09	3 26
Subjects and Sources of Sex Education				
*Friend—total	20	40	05	3 92
*Sister total	17	04	03	—3 82
Sister sex relations	25	00	06	—3 82
*Misc total	01	09	.02	3 33
Sister birth	16	00	05	—3 26
Friend menst	08	30	07	2 97
Misc , sex relations	00	13	.05	2.77
Friend birth	.24	46	09	2 47
Rel menst	08	00	04	—2 72
Mother menst	72	52	09	—2 17
Mother birth	48	33	09	—1 61
Misc menst.	.00	04	03	1 43
Father sex relations	30	.43	10	1.32
*Mother total	48	40	08	—1 05
*Rel total	10	07	03	— .97
Rel., sex relations	15	09	07	— 89
Misc . birth	04	08	04	.88
Rel birth	08	12	06	70
Mother sex relations	30	35	.10	52
Sister menst.	12	13	.06	16

*The starred items are based on 3 questions instead of 1, so there are 70 in each of the contrasting groups instead of 25 as there are for the other questions

The Pearsonian correlation coefficient between the neurotic scores and the different sections of the questionnaire were:

I Childhood + 49± 05
II Marriage + 32± 06
III Pregnancy + 38± 06 (Criterion).

TABLE 3

COMPARISON OF FAVORABLE AND UNFAVORABLE PRIMIPARAE IN RESPECT TO DATA ON CHILDHOOD

Section I

(PE of the difference)

Item	M_1	M_2	PE_D	$\frac{D}{PE_D}$	Reliability C
Total score	56.20	68.96	2.42	5.28	
Home life	1.16	2.16	.19	5.20	79
Mother kind	1.12	2.12	19	5.18	79
Mother irritable	2.37	3.43	21	5.09	72
Enjoyed care of sibs	1.57	2.57	25	4.00	79
Scolded often	2.20	2.92	19	3.71	62
Care of sibs	1.12	2.20	30	3.59	74
Happiness	1.32	2.08	22	3.38	66
Parental harmony	1.32	2.12	25	3.27	82
Mother's time	1.37	2.16	24	3.25	76
Mother consistent	1.67	2.29	.22	2.86	69
Restraint by family	2.60	3.12	20	2.63	67
Mother fair	1.56	2.16	24	2.52	75
Mother answered questions	2.20	3.04	.34	2.49	80
Joined games at school	1.40	1.80	16	2.47	67
Preferred play with boys	2.04	2.48	19	2.28	79
Opportunity to play	1.72	2.16	24	1.84	70
Free to ask mother questions	2.87	3.48	34	1.82	74
Punished often	1.92	2.36	.25	1.77	67
Sex curiosity	2.80	3.16	.25	1.44	77
Father irritable	2.28	2.58	24	1.29	66
Quarrel with brothers	2.08	1.72	.31	—1.16	69
Father kind	1.64	1.88	24	.99	80
Use of opportunity to play	1.80	1.67	20	—.68	59
Reaction to first menst	3.16	3.32	26	.62	78
Father's time	2.32	2.20	27	—.44	74
Housework	2.68	2.60	23	—.35	83
Quarrel with sisters	2.20	2.20			69

The units in this chart are score values on the rating scale from 1 to 5. The higher the score, the more it is associated with an unfavorable attitude on the part of the primiparae. A minus sign, here as before, indicates that the mean of Group I is larger than the mean of Group II, or that a particular item is associated with the opposite reaction of what was expected in making up the questionnaire.

C. The reliability of each question is shown here as measured by the coefficient of contingency.

This indicates a positive relation. It is interesting that neurotic tendency is more closely related to childhood than it is to the attitude toward pregnancy.

A more detailed study was made of the relation to the Neurotic

TABLE 4
Comparison of Favorable and Unfavorable Primiparae in Respect to Data on Marriage
Section II
(PE of the difference)

Item	M₁	M₂	PE_D	$\frac{D}{PE_D}$	Reliability C
Total score	26.16	32.28	1.04	5.91	
Economic security	1.60	2.42	20	4,02	71
Parents approve marriage	1.12	1.96	.21	4.00	82
More social life than before	2.04	2.92	22	4.00	76
Husband likes same people	1.72	2,28	14	3.92	68
Desires career	1.16	1.88	20	3.57	48
Enjoys sex relations	1,56	2.20	18	3.49	79
Liking vs expectation	2.17	2,76	22	2.66	74
Disagrees with husband often	1.96	2.44	18	2.65	70
More money than before	3.40	3.92	24	2,13	73
Wanted to leave home	2,20	1,83	29	—1.27	63
Would re-marry	2.75	3.08	32	1,02	69
Reason for working	2.26	2.06	31	— ,67	78
Preparation for marriage	2.52	2.39	24	— 54	64

TABLE 5
Comparison of Favorable and Unfavorable Primiparae in Respect to Data on Pregnancy Criterion
Section III
(PE of the difference)

Item	M₁	M₂	PE_D	$\frac{D}{PE_D}$	Reliability C
Total score	11.60	25.88	.50	28.69	
Wish to postpone it	1.32	4.08	.24	11.63	70
Would choose preg again	1.17	3.28	21	10,05	76
Fears being kept home	1.12	2,92	.19	9.56	77
Fears labor	1,32	3.40	22	9.39	80
Disposition changed	2.20	4.00	.20	9.00	81
Wants job later	1.04	2.36	.21	6.18	85
Depressed	2.20	3,72	25	6.00	77
Fears expense	1.28	2.46	23	5.11	81

Inventory of the items found most significant for the attitude toward pregnancy Of these, 43 items whose ratio $\frac{D}{PE_D}$ was over 3, *only 8 had equal or more significance for the neurotic tendency.*

These were: husband employed, total attitude toward childhood, home life and happiness in childhood. In marriage the significant items were the total attitude, financial security, liking the same people as the husband, and good sex relations. In pregnancy the significant items were: fearing labor, feeling depressed, and thinking the child will be too great a financial burden.

IV. Discussion of Results

Interpretation

This study shows some of the factors most frequently found with a favorable or unfavorable attitude toward pregnancy in the primipara. It is desirable to know the nature of these associations, that is, which factors are causal in relation to the main attitude, which are symptomatic, and which are related only through a common third factor. It would not be justifiable to draw conclusions as to the nature of the relationships from the present investigation, as it shows only some of the factors between which such relationships do exist. The time sequences, however, are highly suggestive, so in the following discussion, the items are classified according to whether they occur before or during the period of gestation or both.

A. Factors Temporally Preceding Pregnancy.

1. *Emotional impoverishment in childhood.* The mother's early emotional impoverishment is associated with her later unfavorable attitude toward pregnancy just as Levy found it to be associated with an attitude of rejection or over-protection toward the actual child. A close relationship in childhood between the subject and her mother is definitely associated with a favorable attitude, while lack of such relationship is associated with the opposite feeling. The subject's relationship with her father seems much less important. This finding is re-inforced by a similar finding in the study of Stemsrud and Wardwell (9). This may be because the father is away from home so much that strongly emotionalized contacts with him are much less frequent than with the mother. It might also mean that in our present society fewer men than women in a normal group develop extreme emotional attitudes. Having siblings, especially brothers, conditions the subject favorably, but having to care for them too often is an adverse factor. More only children are found in the unfavorable group. Quarrels with brothers

nade no difference either way. Social relationships out-
ne were less important than those within, and probably
uccess *or failure of the more primary family relation-*
total situation is more important than any single factor

ly responsibility. Early responsibility in the form of
iblings is an antecedent factor that is associated with an
attitude toward pregnancy If the subject enjoys car-
lings, it becomes a favorable factor Having to help
ousework was the usual custom of the group studied,
accepted without emotional friction by most of them
g does not correspond to Levy's theory concerning
l attitudes It shows that early responsibility is not
factor if the subject enjoys that responsibility. It also
it the effect of any given responsibility on the subject
by her economic status and personal evaluation of it

education. Sex education, in most cases, occurs in the
woman before her attitude toward pregnancy is estab-
t may be a partial determinant of that attitude, or both
lts of a common cause The results in Tables 2 *A* and *B*
Group I was older than Group II at the time of learning
of sex relations All cases where this information was
fore 10 were found in the unfavorable group. The
may be an advantage for several reasons It may mean
bject had a richer environment as she developed, so her
st in sex was subliminated. It may mean that she lived
home or neighborhood than the girl in the crowded
e attention is forced too early into sex matters Or it
simply that sex adjustment was innately not a serious
r her

g sex information from the mother is not necessarily
Many women who receive this information from their
y receive it in the form of warning against men. A sister
er to the girl's own age and who is not bound by the
f an earlier generation is here shown to be a favorable
the girl gets this information from a friend, or other
rce, either because her curiosity is suppressed at home, or
information is thrust on her outside before she is ready
s likely to be associated with an unfavorable attitude

Previous studies, such as those of Figge (1) and Gleason (4) have indicated that the mother's sex instruction is a factor in the later relationship to her child. This study shows it is also important for the attitude of the prospective mother.

4 *Additional items* There was a significantly greater percentage of Jews in the unfavorable group. A definitely greater proportion of Group II had complaints to make about affairs in general These complaints were chiefly concerned with finances, relatives, or general health More of the unfavorable group used contraceptives at some time or other, and fewer of them said they had planned to have the baby.

B. Simultaneous Factors

1. *Physiological concomitants of pregnancy* Nausea and vomiting, and a more prolonged period of nausea are much more likely to occur in the unfavorably disposed primipara than in the favorable one. While nausea and vomiting in pregnancy doubtless have more than one cause, the results of this study indicate that the psychological-emotional ones are of prime importance

C. Factors that Occur Before and During Pregnancy

1 *Marital situation* The aspects of the marital situation that are associated with a favorable attitude toward pregnancy are· financial security, social and sexual compatibility Here again the woman's adjustment to the whole situation is more important than any single item. A satisfactory general adjustment, however, implies successful adjustment in most of the smaller details of married life.

Levy says that anything that narrows the emotional life of the mother may cause her to be over-protective toward the child. He also says the chief cause of such a narrowing is unsatisfactory sexual or social life in marriage The present study shows that this factor is also operative in producing an unfavorable maternal attitude before the birth of the child Examples of a narrowed emotional life were given in the verbal statements of three of the subjects scored in the unfavorable group who wanted a child because their own mothers had recently died, or because their families were in another city and they felt lonely. This study shows the question of financial security to have relatively more importance than Levy and others have attributed to it.

2 *Neurotic Tendency* Women who resent the fact of their pregnancies are definitely more neurotic than women who do not. Neurotic tendency alone, however, does not account for an unfavorable attitude. This is shown by its lack of relation to many of the items most closely associated with the general criterion

The items associated with a neurotic tendency seem to be more general and subjective than the items associated with the specific attitude toward pregnancy, with the noteworthy exception that neurotic tendency as here measured is consistently associated with lack of economic security.

D *Results Relating to Method.*

1. *Nature of the subject group* It is important to remember that these results apply to a lower middle economic group only Inferences can be made from this to other groups, but the differences must always be carefully watched for.

2 *Interrelation of significant factors* Many of the factors shown above to be closely related to the attitude of the primipara are interdependent. They must not be regarded as separate items, but always as within a related whole. It was previously mentioned that this study cannot indicate the nature of the interrelationship of these factors. With different individuals, different items will assume varying amounts of relative importance A single item can never be considered as predetermining The significance of any one lies in its relationship to the whole complex of factors

3 *The study of maternal attitudes during pregnancy.* This study shows beyond doubt that women's attitudes toward their expected children are widely differentiated and can be examined before the birth of the child, though there is no absolute proof that these attitudes would remain the same after the child is born

4 *The questionnaire method.* The present questionnaire had a weakness which could be eliminated in future investigations of this type This was lack of clarity in some of the questions, due to ambiguous phrasing, and occasionally, to the use of words beyond the understanding of some of the subjects, though most of the difficult words were eliminated in the preliminary form This same criticism holds true of the Clark-Thurstone Inventory While it was usable under the present circumstances, nevertheless it was vali-

dated on a group of college students and should be modified for a group with less education.

The advantages of the questionnaire were that it gave information on the subject over a long range of years. It enabled the writer to examine comprehensively a great many more subjects than would have been possible by free interviews or regular social histories in the same length of time. Its objectivity, as far as the examiner was concerned, eliminates some of the sources of error of other methods of personality study.

This method presents an opportunity for detailed analysis of previous theories, points a way to new theories, and permits study of a large number of subjects with very definite controls This study has definitely shown the questionnaire method can be applied with profit to a field heretofore reserved for case studies and analyses

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A COMPARATIVE STUDY OF SIZE CONSTANCY*

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INTRODUCTION

Sizes maintain a certain stability or constancy of psychological response in man. The size of the image of an object projected upon the retina frequently bears little relation to the ensuing report of the size of the object itself Of two objects in the visual field, the one with the larger retinal image is not necessarily the object judged to be larger. An object is judged as "large" or "small" when the retinal projection of that object and the consequent laws of perspective are at variance with such a judgment. Over a wide range of *retinal changes, however, the integrity of the original size is maintained.*

The present investigation was carried out in order to discover whether size constancy were present in the perceptual response of the monkey, and, if so, to measure this constancy, and to compare the results with those obtained from human children and adults under similar conditions.

Previous work in this field with animals as subjects is rather limited Kohler (9) reports that his chimpanzees correctly chose the larger of a pair of boxes in each of the 20 responses given, when the physically larger box cast a smaller retinal image than the physically smaller box. The side of the boxes facing the animals was 9 x 12 cm., and 12 x 16 cm The distance separating the two boxes varied from 50 to 90 cm The retinal image of the larger box was from 37 to 72 per cent smaller than its comparison box A further study is that of Gotz (5) who found that chicks displayed the same type of perceptual reaction. The chicks chose a larger grain of corn when its retinal area was 1/30 of that of a smaller grain The small corn was placed 15 cm. from the chick and the large

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grain varied up to 169 cm The grains were in the proportion of 4 5, the linear dimensions being 2·2 24.

Research conducted upon children is centered about the problem of the development of size constancy Klimpfinger (8) and Beyrl (1) state that there is a noticeable development in this constancy, that very young children possess it to a slight degree, and that there is a direct relationship with age, the high point coming between the ages of 10 and 15. Burzlaff (3) and Frank (4) feel that children's equations are no different from those of adults and that the differences found result from the method employed. Weber and Bicknell (13) report higher points of equation for children than for adults Comparative findings with adults are reported by these investigators Thouless (12), using only adults as subjects, states that there is a decrease in equation point with age

METHOD AND PROCEDURE

The apparatus duplicated the arrangement used in a discrimination problem A large table 80 cm high, 50 cm wide, and 3 m. 67 cm. long, divided in the center by a partition 20 cm high which ran the length of the table, was placed directly in front of the subjects The table and partition were painted a flat black. The entire outfield was restricted by a white cloth which was hung next to the wall of the room on both sides and to the front of the stimulus table The stimulus objects were two cardboard squares—a standard and a comparison object, which were placed on one side or the other of the partition. These will be described in greater detail below The room lights overhead were always turned on, and additional illumination was provided by two 200 watt lamps directed at the table. This lighting was so arranged that there were no shadows in the visual field When testing the animal subjects a reaction cage was placed flush against the table, the shutter opening of the cage being slightly above the top of the table. When the human subjects were tested, the reaction cage was replaced by a heavy white cloth which enclosed the subjects, and in front of which was placed a beaver-board screen. All positions and distances were kept in the same relative proportion for human and animal subjects Further details and complete measurements of the apparatus will be found in a paper by Locke (10).

The animal subjects were three male Rhesus monkeys, 4, 4½, and 6 years of age. These animals followed the regular routine adopted by the Columbia Animal Laboratory as described by Locke (10) The monkeys had previously been used in discrimination experiments and were well adapted to the experimental situation The three children used as subjects were two girls—one aged 4 years 9 months, the other aged 4 years 1 month, and a boy aged 4 years 3 months. The adult subjects finally selected were six graduate students These individuals were cooperative and expressed an active interest in the experiment.

The procedure adopted with the animal subjects can be divided into the training series and the critical series. The monkeys were transported in a rolling truck from their living quarters to the experimental room. In this room they were trained to jump into a door in the rear end of the reaction cage, and then to face the wooden shutter in the front of the cage. When the shutter was raised the animals were in position to react. The method used was essentially a discrimination method in which the animal would choose one of two presented stimuli

The preliminary procedure was to train the animals to choose the larger of two gray cardboard squares, one being placed on each side of the dividing partition. These stimulus objects were respectively 11 cm. square, and 4½ cm. square. They faced the monkeys *in a frontal parallel plane, being held upright by blocks glued to* the back. The monkeys would indicate their choice by reaching for a raisin in one of two small boxes placed on the table on each side of the partition. The correct and rewarded choice of box would correspond to the side on which the larger stimulus square was placed. Training continued for a considerable number of trials but the results were very poor, so this reaching response was abandoned in favor of a pulling-in technique. The sizes of the squares were changed to 16½ cm and 10 cm A recess was sunk in the supporting block of the stimulus squares and strings were attached to these blocks. When the animal pulled the string of the correct cardboard it would obtain a raisin which had been inserted in the block. With this technique the monkeys learned very quickly to choose only the larger of the two objects. Different size stimuli were used, the dimensions being diminished at each change The final sizes were 16½ cm square for the larger object, and 15 cm square for the smaller object. The blocks, which now faced the animals, measured 5 x 5 cm for the larger cardboard and 4½ x 4½ cm for the smaller, both blocks being 7 cm deep. Since the table top was at the eye level of the animals only the front face of these blocks was seen. Table 1 reveals the number of responses required with each technique to learn to choose the larger of the two cardboards. The final number of trials to learn is obviously quite specific because of the element of transfer from one situation to the other. However, from a methodological point of view, the use of a pulling-in technique was far superior to a reaching technique

TABLE 1

SIZE OF STIMULI IN CENTIMETERS, NUMBER OF TRIALS, AND LAST DAY'S PERCENTAGE OF CORRECT CHOICE OF THE LARGER OF THE TWO GIVEN STIMULUS SQUARES

Results with the reaching technique and the pulling-in technique

	Reaching		Pulling-in							
	11 v 4½		16½ v 10		15 v. 10		15 v 12		16½ v 15	
Animal	N	%	N	%	N	%	N	%	N	%
Hector	754	69	113	95	34	96	30	90	61	100
Menelaus	767	63	114	94	30	100	11	100	54	95
Ulysses	742	60	144	86	30	93	13	92	29	90

After the animals had learned to respond to the larger of the two stimuli, the smaller square was placed 55 cm from the animal and the larger one was moved back, away from the animal, in successive trials The fixed distance of the smaller stimulus object was chosen so that the animal could not see the raisin in the well of the block, and yet not be too far away The reward was placed in the blocks of both the standard and comparison stimuli As the larger square was moved back from trial to trial the retinal image of the square diminished until a point was reached at which the image of the physically larger square was smaller than that of the physically smaller square If constancy of size was a function in the perceptual mechanism of the monkey, it would continue to react to the physically larger square regardless of the shrinking retinal size, *and even though the retinal image was smaller than that of its comparison.*

In the critical series it was desired to discover up to which point this phenomenon of size constancy was operative. Measurements were taken by attaching meter sticks along both outside edges of the table. Thus the distance from the eye of the subject to the stimulus could be read at a glance. Because the animals were rewarded at every response, there being no "correct" or "incorrect" choice, position and alternation habits developed. It was necessary to intersperse the original large-small discrimination with the critical responses in order to overcome these disturbing habits. The procedure finally adopted was to present the animals with both standard and variable in the same plane for four trials, requiring a response to the larger, and then to give one critical trial in which the larger stimulus object was separated from the smaller in increasing units of 5 cm. The responses in which the stimuli were separated in space are herein mentioned as "critical" responses. In the presentation of the stimuli a modified method of limits was used.

As the distance between stimuli increased the task of choosing the larger one became more and more difficult as evidenced by *extensive comparison behavior. Finally a point* was reached at which the animals would choose the physically smaller object as being the larger, which indeed it was from a phenomenal point of view. In a descending series the same procedure was followed by starting with a distance large enough to insure a choice of the physically smaller object, and then decreasing this distance to a *point* at which the *animal* would shift to the physically larger stimulus. In all, one animal, Hector, was given 86 critical trials—*43 in an ascending series and 43 in a descending series. The other* animals were given 90 trials—45 ascending and 45 descending.

In addition to the usual controls, such as shifting the stimuli from one side of the partition to the other, changing the stimulus objects for others of the same size and so on, it was necessary to make sure that the animals were not responding to the nearer of the two objects. Occasionally other sizes were interspersed as a further check.

The procedure with the human subjects was to instruct them to report naively the appearance of the stimulus objects. The physical sizes were to be ignored, and the response of "smaller" or "larger" was to refer to the way the objects appeared. The analogy was drawn to looking from the roof of a very high building and noting the very small appearance of the size of the people below

The subjects were then told to report which square appeared larger—not the one that was larger, nor the one they thought should be larger, but just how they seemed to look The task was difficult for many individuals, only about half of those originally chosen were able to disregard the physical size.

When the children were tested, the stimulus objects were placed some distance apart and the children were asked which one looked bigger It was unnecessary to give further instructions, for these subjects readily and consistently reported in terms of appearance The indicator response used with the children was to point to the side of their choice.

The method of limits was used with the human subjects, the final distances being an average of 5 ascending and 5 descending trials Motivation was poor with one child, Frank. The strings attached to the blocks of the stimuli were placed in the same manner for the human subjects as they had been for the animals, although the human subjects did not handle them.

RESULTS

It will be recalled that the physically smaller object was placed at a fixed distance, 55 cm, from the subject and the physically larger object was moved back and away from the subjects until a point was reached at which the judgment of "larger" would favor the physically smaller square. The averages of the ascending and descending series for all subjects are presented in Table 2 These scores represent the distance at which the response shifted from physically larger square to physically smaller square It will be seen that there are no typical differences in the subjects studied The scores of the monkeys overlap both those of the human adults and children. These scores can be transmuted into ratios in order to discover to what extent size constancy is present in the response of these subjects.

If there were no constancy, as soon as the physically larger stimulus object cast a retinal image which was smaller than that of the physically smaller stimulus object, the subject would shift in his judgment and report the latter as being of larger size If there were complete constancy, the physically larger stimulus object could be withdrawn to a distance approaching the limit of visual acuity

TABLE 2

AVERAGE DISTANCE OF JUDGMENT, AND SIZE IN LOGARITHMS OF RETINAL IMAGE FOR *E* (EQUATION SIZE), *P* (PROJECTION SIZE), AND *S* (STANDARD SIZE), FOR ALL SUBJECTS

	Subjects	Distance	E-size	P-size	S-size
Animals	Hector	94.79	1741	.1582	.2727
	Menelaus	111.54	1479	.1345	2727
	Ulysses	74.84	2205	2004	2727
Children	Ann	87.50	1886	1714	2727
	Lee	87.50	.1886	1714	2727
	Frank	140.00	.1179	1071	2727
Adults	CS	79.17	.2084	.1895	.2727
	PE	100.84	.1636	1488	2727
	HA	81.67	2020	1837	2727
	HS	95.84	.1722	.1565	.2727
	JR	71.67	2302	2093	.2727
	JH	92.30	.1784	1622	2727

and the subject would still report it as being the larger one. It becomes necessary to measure the image that these objects cast on the retina in order to discover whether the psychological judgment of "larger" or "smaller" varied as these retinal images vary in size.

According to Southall (11) the size of the retinal image of an object is calculated in terms of the apparent size of the object, the latter being measured by the visual angle it subtends at the eye. Instead of the visual angle itself, the tangent of the angle is here used. Thus the apparent size of an object is measured by dividing *the linear dimension of the object by the distance from the eye.* The use of this principal point angle presents an advantage. Southall states that since the positions of the principal points remain sensibly stationary in the act of accommodation, the reduced length of the eye-axis may be considered as constant in the same individual. Hence the peculiar significance of the principal point angle consists in the fact that according to this formula, this angle may be taken as a measure of the size of the retinal image which is independent of the state of accommodation of the eye. Thus, for a given individual, all objects which have the same apparent size as measured at the principal point of the eye will produce retinal images of equal size.

We now have two objects of different sizes standing at different distances from the eye, and the retinal images of these objects is measured by $\frac{h}{d}$ or the height of the object divided by its distance from the eye. The nearer object was 55 cm from the eye and its height was 15 cm This smaller stimulus object was the standard, the size of its retinal image will be designated here as S The 16½ cm. square was moved back a given distance until the subject stated or indicated that it appeared smaller, this distance then becomes the denominator in the above equation. The equation point is transmuted into terms of its retinal image, designated as E.

The zero point of size constancy would be seen if E and S coincided, the point of complete constancy must be arranged with reference to the entire stimulus situation. To stay within the limits of the situation, complete constancy must be represented by the hypothetical retinal image of the standard if it were seen at the distance chosen for the variable We must project S to the distance obtained with E and derive the projection size or P. The equation point can then range between the limits of the standard at fixed distance and the projection of that standard at the obtained distance. This relationship can be expressed in terms of direct percentage or in more elaborate terms. The treatment of the data here presented is based on that of Brunswik (2), who gives its complete mathematical derivation. This "intention ratio" or I-ratio follows:

$$\frac{\log S - \log E}{\log S - \log P} = \text{scale of constancy.}$$

In short, the physical measurement minus the phenomenal measurement (the obtained) divided by the physical measurement minus the projection measurement (the theoretical) yields a measure of size constancy ranging from zero to unity If the ratio is high, approaching unity, it indicates a high degree of size constancy; if the ratio is low it is indicative of a low degree of size constancy.

In Table 2 the data for the various retinal images are presented, and in Table 3 the essential measurements for the intention ratio and this I-ratio are given The I-ratio scores range from 6403 to 8972 for all subjects. This indicates a fairly high degree of size constancy. The range for the adults is from .6403 to 8815, the range for the children is .7941 to .8972, that for the monkeys is from 6897 to 8656 In the present situation there are no group differences in the size constancy response Animal scores and human scores overlap

TABLE 3

LOGARITHMIC CALCULATION AND RESULTING I-RATIO (INTENTION-RATIO) FOR ALL SUBJECTS

Subjects		Log S - Log k	Log S - Log P	I-ratio
Animals	Hector	19489	23648	8241
	Menelaus	26572	30697	8656
	Ulysses	09228	13379	6897
Children	Ann	16015	20168	.7941
	Lee	16015	20168	7941
	Frank	36418	40590	.8972
Adults	CS	11679	15808	7388
	PE	23191	26309	8815
	HA	13034	17158	7596
	HS	19966	24118	8278
	JR	07358	11492	6403
	JII	18430	22564	8168

considerably, and the scores of the adults are essentially the same as those of the children.

Since a previous study by Locke (10) on color constancy revealed a very clear distinction between animal and human adult scores, a further discussion of the results is necessary In addition, previous findings of other investigators (1, 12, 13) indicate differences in scores with age differences, an observation which is not corroborated here.

In the above mentioned study on color constancy it was felt that the differences in group scores between human beings and monkeys *were related to the attitude differences which are known to determine* the scores of human beings. Many investigators report that a distribution of color constancy scores is bimodal, indicating different perceptual attitudes Holaday (6) found that such differentiating attitudes could be induced in a size constancy situation. One should expect somewhat the same results in size as in color constancy not only differences between animal and human scores but also attitudinal differences in the human subjects.

Further, Beyrl (1) found that age of children and size constancy score are related, and Klimpfinger (8) indicated a bimodal distribution in size constancy similar to that in color constancy Again such relationships are not found by the present author

There are a number of alternate explanations for these differences: there is a possibility that size constancy and color constancy are two different functions, constancy of size may be a simpler function than that of color, and a third alternative is that the results obtained with the present method of derivation are too limited in scope. In view of the existing body of experimental evidence there is no reason to postulate separate functions for perceptual constancy That sizes involve a simpler group of attributes than colors do is readily admissible, nevertheless the experiments quoted above seem to indicate that the perceptual functions of both are close A fruitful and simple explanation is that the present experiment involed too simple a situation.

One point of technique can be noted the immediate visual field was at the eye-level of the subjects. Katona (7) reports that eye-level judgments of a field result in lower scores than those obtained with any other method of regarding that field In addition, the visual field was a relatively uncomplicated one consisting of table, partition, and stimulus squares all limited on three sides by the white cloth. This may have been enough to preclude the possibility of group differences The suggestion, then, is that if the field were more complex such differences could make themselves seen.

SUMMARY AND CONCLUSIONS

1. A similar stimulus situation was presented to three Rhesus monkeys, three children, and six human adults, and the size constancy responses of each were determined.
2. All groups revealed size constancy to a fairly large extent.
3. There was no differentiation between the intention-ratio scores of animals, children, and adults.
4. It was suggested that the experimental situation may have been too simple to permit such group differences as may exist to show themselves.

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NOTES ON SYMBOLIC BEHAVIOR IN A CEBUS MONKEY (Capucinus appella)*[1]

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Behavior which involves the responses of animals to "symbols," "reduced cues," and other "abstract qualities," presents opportunities for the experimental analysis of principles and hypotheses which are of great importance to psychology. Among the principles involved by such behavior and which might be investigated are Hollingworth's principle of redintegration (1, 2), Korzybski's concepts of levels of abstraction (6), the concepts of "relata" and abstractions as formulated and demonstrated by Kluver (3), and Pavlovian principles of conditioned responses (7). The available methods and procedures generally employed in comparative psychology have not always been entirely adequate for the investigation of these functions of abstraction and association. Furthermore, animals customarily employed in psychological laboratories have not shown evidences of the more intricate processes of abstraction or "symbolism." The observational and experimental notes herewith reported relate most closely to such experimental work as that of Kohts (4, 5), Kluver (3), and Wolfe (9). It was because of close acquaintance with the work of Wolfe while it was in progress that the trading behavior of the subject of our experiments was observed and evaluated.

The problem with which we have been concerned is that of determining one phase of the capacity of a capuchin monkey to establish associations or "conditioned responses" to differently colored poker chips, and to determine the ability of the monkey to use these chips as a means of getting specific kinds of food. We were equally

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[1] Experimentation was conducted at Bard College and in the Animal Laboratory, Department of Psychology at Columbia University. The authors are deeply appreciative of the encouragement, suggestions, and assistance given by Professor C. J. Warden.

interested in demonstrating the possibilities of using the trading technique with monkeys in experimental work upon problems involving motivitation, food preferences, discrimination, choice behavior, learning, and anticipatory and delayed reactions

The monkey, "Trader," was a male *Capucinus appella,* a Cebus monkey sometimes called "ring tail," more specifically known as a weeper capuchin He was first observed in July, 1934, at the San Diego Zoological Garden At that time he was attracting considerable attention in the Garden by his generalized habit of giving any kind of small object to visitors in exchange for food The experimental possibilities of this animal were recognized, and he was purchased. By using this animal we hoped to learn to what extent his trading behavior could be employed to investigate the behavioral capacities of New World monkeys. As it was on the basis of this kind of response that Kohts and Wolfe conducted their experiments on chimpanzees, we sought data which would be comparable for monkey and chimpanzee.

We have no definite information as to how the trading habit was first established It was assumed by the Garden authorities that Trader was taught this habit by his former owner. The owner gave the animal to the Garden because he became a dangerous pet.

PROBLEM

The specific problem was to ascertain whether Trader could differentiate between poker chips of different colors, and form associations between these chips and particular kinds of food

BASIC BEHAVIOR MECHANISM

The generalized trading habit and behavior of the animal can best be described in a definite situation. The experimenter would hold out his hand to the monkey as a cue for trading, at times reinforcing this stimulus by words such as "Give me something, Trader" or by gestures. The animal would respond by collecting and offering to the experimenter almost any small object which he could handle. Small sticks, handfuls of sawdust, trash, straw, pieces of paper, the food containers, and any other available object would be proffered. If the object were refused, something else would be collected and presented. Frequently, after having given an object Trader would hold out his hand for the anticipated reward. If the object which the monkey offered was taken but no reward given the monkey would seek other things and add them to that already given. (This seems to be a type of reinforcement.) After a number of responses in which the animal had given objects to the experimenter but had not been rewarded, the trading response would be temporarily extinguished The response would re-appear spontaneously after a short delay or if conditions were changed Sometimes temper tantrums would result after unrewarded responses.

PROCEDURE No 1

The following experimental situation was arranged Three containers were placed in three corners of a room which was 10 feet square. Twenty-five or 30 poker chips of one color were put into each of these containers The chips were red, white, and blue in color and of the same size. The chips were grouped as to color in the containers, and the latter were systematically rotated from one corner to another in order to prevent the formation of position habits The experimenter sat in the center of the room facing the corner of the room which had no chips, and controlled the rewards Every precaution was taken to avoid giving the animal directional cues other than asking him for something and thus motivating him to respond Trader was released in the room and allowed free range He would come to the table and sit until told to "get something," or he would explore various parts of the room. When properly motivated, he would go to one of the containers and get one or more chips and bring them to the table and give them to the experimenter. In exchange, he was given a food reward. If a red chip or chips were brought he was given about one-twenty fourth of an orange, if a blue chip was brought he was given a shelled peanut; and if a white chip was brought he was given about one-thirtieth of a banana.

Motivation was controlled by withholding food from the animal for 24 hours before experimentation Usually he was hungry and worked well, but there were exceptional days The number of trials given each day depended upon the speed and directness with which the animal worked When he began to slow up or to explore the room generally rather than work in the experiment, the work for the day was stopped.

Qualitative Results The generalized trading responses soon became specific, and poker chips alone instead of objects in general were given by Trader in exchange for food He usually worked very rapidly He would jump to the floor from the experimental table, rush to a chip deposit, pick up one or more chips and rush back to give them to the experimenter in exchange for food. He was given food rewards which corresponded to the predetermined association of a food with a color Characteristically there would be a series of responses during which the same color of chip was given, and this seemed to indicate a temporary preference for the food which was received in exchange. For example, Trader would give blue chips on certain days for 15 or 20 times in succession and apparently until he became satiated with peanuts, then he would shift and give the symbols which corresponded to oranges or bananas Since shifts occurred during experimental periods, and from day to day, different preferences were shown It can be seen that these preference series cannot easily be demonstrated statistically with the data which we have available.

Certain scoring possibilities as refinements of our work are worth noting. (1). Speed of response might be measured. (2). The number of chips given in response to the amount and kind of food could be recorded (3). The amount of work done for a particular kind of chip could be measured (Wolfe, 9) (4) The number of possible exchanges of different symbols before the consummatory exchange for the true incentive could be ascertained In further work we expect to test such measurement possibilities

At times Trader would obviously make errors: he would bring a particular color of chip, present it, and without waiting for the reward, dash back for another chip of the same color At other times he would bring a chip, take the food reward but immediately throw it down and behave "as if" he had anticipated another kind of food (Tinklepaugh, 8) Sometimes he would present the same kind of chip repeatedly but again he would shift to another kind of "symbol" When strongly motivated, Trader would bring for exchange, two, three or four chips and do this in spite of the fact that only one chip was required for the reward This non-parsimonious behavior would occasionally persist for a series of responses or trials

TABLE 1

PROCEDURE No 1

Number of exchanges, per cent offer of chips, and number of times food was accepted or refused by the monkey

		Orange			Peanut			Banana		
Day	N	%	Acc	Ref	%	Acc	Ref	%	Acc	Ref
1	22	0	0	0	45	10	0	55	10	2
2	49	24	12	0	33	16	0	43	17	4
3	45	24	9	2	29	13	0	47	21	0
4	33	37	11	1	24	8	0	39	11	2
5	23	35	8	0	13	3	0	52	12	0
6	64	33	11	10	31	20	0	36	18	5
7	48	46	8	14	54	26	0	0	0	0
8	43	30	5	8	70	30	0	0	0	0
9	45	31	11	3	27	12	0	42	10	9
10	43	23	7	3	30	13	0	47	17	3
11	39	21	4	4	38	15	0	41	10	6
12	41	33	2	11	30	11	2	37	12	3
13	49	22	0	11	31	15	0	47	20	3
14	32	50	7	9	16	5	0	34	11	0
15	16	13	2	0	6	1	0	81	13	0
16	6	0	0	0	50	3	0	50	3	0
17	25	12	3	0	24	6	0	64	16	0
18	15	20	3	0	33	5	0	47	7	0
19	11	27	3	0	18	2	0	55	6	0
	649		106 +	76		214 +	2		214 +	37
	Totals		182			216			251	

Quantitative Results Table 1 gives the resulting responses during 649 trials with Procedure No 1 The number of trials carried out during a single day ranged from 6 to 64 In this free choice situation, Trader gave a white chip 251 times and received a reward of banana, gave a blue chip 216 times and a red chip 182 times for rewards of peanut and orange In 15 of the 19 sessions the percentage of choice was highest for the white chip which was exchanged for the banana On 12 days the second highest per cent was the exchange for a piece of peanut, and on 6 of the remaining days the second choice was the orange Orange as a reward was refused 76 times, the peanut reward was refused 2 times, and the banana reward was refused 37 times. The indication is that the descending order of food preference is banana, peanut, and orange. It would seem permissible to assume that the anticipation of a particular food reward was a determining factor in selecting the corresponding "symbol"

PROCEDURE NO 2

This and the following series were carried out about one year after the first series. For this work, Trader was placed in an experimental cage equipped with a shutter. Small roulette chips were used as stimulus objects. There were twenty-four chips, 8 red, 8 blue, and 8 white, placed haphazardly on the floor of the experimental cage with the monkey The chips were renewed at every third or fourth exchange Approximately equal amounts of food consisting of oranges, peanuts, and bananas were used as units of incentive, and the same associations were made as in the previous experimental work, namely, red for orange, white for banana, and blue for peanut.

After a preliminary period of general trading for the purposes of adaptation, the following specific procedure was employed. When the shutter was raised, Trader would present a chip to the experimenter and in exchange he was given a corresponding unit of food The shutter would then be lowered For the most part during the experiment, Trader would offer only one chip but sometimes he would offer two or more When more than one chip was offered, if they were of the same color they were accepted and the exchange of food was made; if they were of different colors they were thrown back into the cage and no reward was given.

Qualitative Results. When the shutter was raised, Trader would pick up a chip and offer it to the experimenter At times he would begin to reach for a chip, hesitate in a manner characteristic of choice reactions in animals, and then either pick up that chip or reach for a different one He would then turn and give the chip to the experimenter Trader would frequently go to the opposite side of the cage and get a chip, although there were several chips of the kind selected lying near the shutter. This may be a carry over from the former experimental situation. Occasionally he would hold a chip in his hand in the period between exchanges, but he would not necessarily offer that chip when the shutter was raised. He would either give the chip to the experimenter or he would drop it and reach for another one or he would hold it in one hand and present a chip with the other hand If a chip was put into the hand of the experimenter and it was accidentally dropped, he would get another, usually of the same color, and replace the one dropped by the experimenter. Occasionally the experimenter would be slow in withdrawing his hand from the cage after the chip had been presented, and under these conditions, Trader would often select another chip of the same color and add it to the one already given May we again assume that such action indicated a tendency to reinforce the previous behavior in order that a particular result might be achieved?

Trader would not always eat the food after an exchange had been made and sometimes he would not even take it from the hand of the experimenter Infrequently he would repeat on chips although he would refuse the corresponding food This fact and that of the trading activity which could be produced when the animal was not hungry indicate that trading *per se* in relation to the facilitation by the experimenter had a reward value separate from the food It might be compared to a kind of play behavior which derives its reward from the intrinsic activity or from social exchanges

Quantitative Results Table 2 gives the results obtained during

TABLE 2

PROCEDURE No 2

Number of exchanges, per cent offer of chips, and number of times food was accepted Only orange refused

		Orange			Peanut		Banana	
Day	N	%	Acc	Ref	%	Acc	%	Acc
1	92	37	24	10	34	31	29	27
2	53	24	10	3	38	20	38	20
3	107	31	25	8	37	40	32	34
4	111	36	41	0	32	35	32	35
5	150	38	57	0	44	66	18	27
6	75	37	28	0	39	29	24	18
7	88	42	37	0	27	24	31	27
8	130	38	49	0	36	47	26	34
9	101	30	29	1	35	35	36	36
	907		300	22		327		258

907 exchanges of chips for food. The number of exchanges ranged from 53 to 150 indicating more strictly controlled conditions and a higher degree of motivation than that in the previous series. There were no refusals of the peanut reward nor of the banana reward, but the orange incentive was refused 22 times. The responses, however, do not present a clear picture of food preferences. Trader presented the red chip for orange 322 times, he presented the blue chip for peanuts 327 times, and he made 258 presentations of the white chip for banana. From the point of view of refusals, peanuts and bananas were preferred, whereas from the point of view of the frequency of response, bananas were traded for least often. It may be stated that bananas were included in the daily feeding schedule of the animal. These results do not entirely confirm the food preferences shown the previous year but shifts in food preference are to be expected, especially with changes in the basic diet of the animal.

Trader would occasionally offer a "run" of chips, i.e., five or more exchanges of one type of chip for a particular kind of food. Coefficients of mean square contingency were computed for all exchanges during this experimental period. Since the number of classes is limited to 3, this coefficient cannot exceed .816. The coefficients obtained for nine days were .18, .47, .18, .13, .17, .28, .25, .09, and .24. These coefficients indicate a slight tendency for the monkey to offer a chip of the same color as that last given. This slight perseverative tendency may be a function of the size of the reward.

PROCEDURE No. 3

In order to discover to what extent chips were functioning as "symbols," a chip with a very different reward value was introduced into the experimental series. A green chip was added with bread as the associated reward. Bread was chosen because it was observed that this food was not eaten when given as a part of the monkey's basic diet. Twenty-four chips were used as in Procedure No. 2, but the number of chips of each color was reduced to 6 instead of 8, the chips were red, blue, white, and green. Prior to the first consecutive series of experiments no food was given the animal for 36 hours. Table 3 gives the results of 150 exchanges grouped in units of 10 exchanges each. In the beginning, Trader

TABLE 3

PROCEDURE No 3

Number of exchanges when bread chip was added Animal 36 hours hungry Results given in units of 10

	Orange	Peanut	Banana	Bread	Bread Refused
1	3	4	1	2	0
2	3	5	0	2	0
3	3	2	2	3	0
4	0	2	4	4	0
5	3	2	3	2	0
6	2	2	4	2	0
7	2	2	3	3	0
8	4	2	2	2	2
9	2	5	2	1	1
10	2	3	2	3	1
11	5	4	0	1	1
12	2	2	2	4	0
13	3	4	2	1	0
14	2	3	3	2	1
15	1	6	0	3	3

ate the bread given him in exchange for the green chip, possibly because of a high degree of hunger He then refused the bread after a few exchanges, then started eating it again, and finally refused it a second time. On the following day this procedure was repeated after two hours of abstinance from food Table 4 gives the results of 120 further exchanges In this series Trader never

TABLE 4

PROCEDURE No 3

Second series with bread chip Animal 2 hours hungry No bread eaten Results given in units of 10.

	Orange	Peanut	Banana	Bread
1	3	3	2	2
2	3	5	2	0
3	2	5	2	1
4	2	2	2	4
5	2	3	5	0
6	5	2	1	2
7	6	2	1	1
8	0	3	4	3
9	0	5	3	2
10	2	3	2	3
11	4	1	2	3
12	2	5	1	2

ate the bread He would either not touch it at all or would take it from the experimenter and throw it on the floor. In both instances the animal continued to offer the green chip until the end of the experimentation In terms of frequency of response, the bread was chosen third on the first day and fourth on the second day

The following question arose If chips serve as "symbols" for various foods and one of the foods is definitely not preferred, why should the monkey continue to offer the "symbol"? It was thought possible that the act of trading *per se* might be sufficient motivation for the animal to continue exchanging the green chip even though bread had a low incentive value In consequence of this consideration, the following procedure was introduced.

PROCEDURE NO. 4

Again there were 6 chips each of red, blue, and white and to these were added 6 yellow chips If Trader offered a yellow chip it was thrown back into the cage, the shutter lowered, and no food given. Table 5 gives the results of 120 exchanges following the overnight period of food deprivation. The yellow chip was offered 29 times *but in 10 of these exchanges it was the same chip that had just been returned!* The decrease in the frequency of the presenta-

TABLE 5

PROCEDURE NO 4

Number of exchanges when no-reward chip was added. Numbers in parentheses indicate frequency of return of same chip Results kept in units of 10

	Orange	Peanut	Banana	No-reward
1	2	2	2	4 (1)
2	2	3	3	2
3	2	2	2	4 (1)
4	2	0	2	6 (4)
5	2	1	1	6 (3)
6	6	2	2	0
7	4	3	1	2
8	7	1	1	1
9	4	2	2	2 (1)
10	6	4	0	0
11	5	4	1	0
12	3	4	1	2

tions of this chip as the experimental series continued is clearly evident. The repeated giving of the same "no value" chip might be interpreted as a kind of hypothesis which had to be broken down A second interpretation is that this might have been a "persisting non-adjustive reaction." If a criterion of learning of 27 out of 30 exchanges be employed, then regarding the trading from the 50th exchange until the end of the series, it may be said definitely that there was an effect which prevented the non-reinforced or non-rewarded "symbol" from being used in the exchanges. During the last 70 responses, the yellow chip was offered only 7 times or on the average of 1 time out of 10. Further experimentation is necessary before definite conclusions can be drawn

When possible, it is planned to continue these experiments along similar lines with a small group of capuchin monkeys. It is hoped that the present preliminary report will be of interest and of value in stimulating experimentation along the many suggested lines

SUMMARY

It has been demonstrated that trading or exchange responses resembling those reported in chimpanzees by Kohts (4, 5) and Wolfe (9) have been shown to lie within the behavioral capacities of a Cebus monkey. Beginning with a generalized trading response in which any object was exchanged for food, differentiation occurred until a specific object was traded for food The evidence indicated that after a large number of trials, an association may be established between a particular "symbol" and a given kind of food. The evidence is not conclusive on this point.

Seemingly a large component of the motivation of this behavior resulted from the residue of the original non-discriminating trading habit, from the incentives offered by gestures and voice of the experimenter, and exploratory responses with reference to unfamiliar objects However, it can be noted that when a disliked food was included, the percentage of the responses to the corresponding chip, although not zero, was lowest of all the other chips. Likewise, when no reward followed the presentation of a chip, there was a tendency for responses to that chip to become extinguished

Further experimentation is planned along the lines of this preliminary report

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THE GENERALIZATION OF CONDITIONED RESPONSES: II *THE SENSORY GENERALIZATION* OF CONDITIONED RESPONSES WITH VARYING INTENSITIES OF TONE*

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Introduction

In a previous study of the writer (11) the gradient of generalization with varying *frequencies* of tone was experimentally determined The interesting question arises as to whether a similar gradient of generalization is obtained when other aspects of the conditioned stimulus are varied A generalization of *intensity* is constantly assumed in psychological theory but experimental evidence concerning it has never been obtained Bechterev (4) states that " . it was revealed, during the inculcation of association reflexes, that the central excitation produced by the stimulation very quickly extends to all stimulations of the given organ and to *all degrees of intensity*[2] of those stimulations" (p 216). That generalization of this sort exists is suggested by numerous experiments on intensity discrimination by the use of conditioned-response techniques, particularly with lower animals. Here the discrimination of intensity does not appear dramatically on the first trial, but differentiation is established only after a long and laborious training process [cf Razran (21) and Razran and Warden (22) for a review of these researches]

While Pavlov (20) does not discuss the *generalization* of intensity, he does report the remarkable *differentiation* of intensity which can be obtained. He quotes an experiment of Tihomorov (20, *A*).

> It was found that any definite degree of intensity of a sound could easily be made into a stable conditioned stimulus and

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[1] This study was conducted in the research unit of Professor Clark L Hull, to whom the writer is grateful for advice and criticism

This is the second of a series of studies presented as a dissertation to the faculty of the Graduate School of Yale University in partial fulfillment of the requirements for the degree of Doctor of Philosophy in psychology, 1936 (See 11, 12, 13)

[2] Italics the present writer's

> could be differentiated from slightly higher or slightly lower intensities of the same sound . Thus it was found that an intensity very closely approaching the one employed as a positive conditioned stimulus could be differentiated by the dog with *an absolute precision even when a pause of 17 hours was made between the two stimuli.*[3] The experimenter found himself able to detect a difference between these two intensities of the sound only when they succeeded each other immediately (p 135)

The possibility of cues or other artifacts was considered improbable by Pavlov, although he states:

> Unfortunately these experiments were conducted in our old laboratory where the effect of the inhibitory stimulus was easily disturbed, and it must be left to the future to repeat these experiments under more perfect conditions in our new laboratory (p. 135)

The investigation of generalization of *intensity* is particularly interesting from a theoretical point of view Pavlov developed his theory of irradiation to explain *spatial* irradiation. According to this formulation, generalization results from a spread of excitation over the cerebral cortex:

> The different sensory places on the skin must be regarded as projecting themselves upon corresponding areas in the cortex of the hemisphere (p 154) "It may be assumed that each element of the receptor apparatus gains representation in the cortex of the hemispheres through its own proper central neurone, and the peripheral grouping of the receptor organs may be regarded as projecting itself in a definite grouping of nervous elements in the cortex A nervous impulse reaching the cortex from a definite point of the peripheral receptor does not give rise to an excitation which is limited within the corresponding cortical element, but the excitation irradiates from its point of origin over the cortex, diminishing in intensity the further it spreads from the center of excitation . Just as the initial point of cortical excitation becomes connected with the centre of the unconditioned reflex, so also do the secondary points of cortical excitation, and this leads to the formation of many accessory reflexes These reflexes decrease progressively in strength with increasing distance of the secondarily excited areas from the point of primary cortical excita-

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[3] Italics the present writer's

> tion, since the magnitude of the conditioned reflex is rigidly determined by the intensity of excitation" (p. 186).

Generalization of this type, while improbable, and "like no phenomena yet observed in nervous tissue by the physiologists" (Guthrie, 9), might occur with spatial generalization of the type investigated by Bass and Hull (3) Neurological evidence does demonstrate a spatial localization upon the cortex of various areas of the body The theory might even be applied to generalization of tonal frequency, previously studied by the writer (11), although here the evidence is still questionable [Cf Davis. "No (cortical) localization of response with respect to the pitch of a pure tone has been detected" (7, p 982)]. With *intensity* generalization, however, a theory based upon irradiation over the cerebral cortex is obviously inadequate. The significant variables here are not spatial, but are those described by Nafe (19):

> Thus an increase in the intensity of stimulation will be followed by an increase in frequency of discharge in each fiber, an increase in the adaptation time for each fiber, an increase in the number of active end-organs per unit of area, an increase in the area affected and consequently in the number of end-organs activated, an increase in the abruptness of discharge, and an increase in the tendency of the individual fibres to discharge together (p 1040)

Lucas (18) long ago clearly demonstrated that altering the intensity of the stimulus alters the number of active fibres. The frequency aspect is especially stressed by Adrian (1, 2).

> Provided that there is nothing to distract our attention the intensity of the sensation at any moment turns out to be proportional to the frequency of the impulses in the sensory nerve fiber (2, p 114)

Investigation of generalization with variations in the intensity of the stimulus thus affords an excellent way of testing the general validity of the phenomenon of generalization, in a situation where the Pavlovian explanation in terms of a cortical "spread" of some neural process is untenable

APPARATUS

The apparatus used has been previously described (11). The galvanic skin reaction (Tarchanoff method) was used as the index of conditioning. The unconditioned stimulus was an electric shock. Sound stimuli, produced by the General Radio beat-frequency oscillator, were employed as conditioned and accessory stimuli. The tones were received through earphones. The subjects were seated in an adjoining sound-proof room.

The time relations were maintained the same as in the previous experiment. The conditioned stimulus was presented for 400 milliseconds. After a pause of 95 milliseconds, the shock stimulus, lasting 75 milliseconds, was given. The reinforcements and test stimuli were presented at approximately one-minute intervals, varied systematically ten seconds in either direction to prevent temporal conditioning.

PROCEDURE

The investigation of intensity generalization is rendered extremely difficult by the fact that intensity itself has a marked influence on the magnitude of response. This has been shown for conditioned salivary responses by Kupalov, Lyman and Lukov (16) and by the writer (14) for conditioned galvanic skin response. The technique which seemed to counteract this difficulty most satisfactorily was to select test stimuli spaced on a scale of intensity by equal numbers of just noticeable differences. One group of subjects could then be conditioned to the strongest intensity and an equated group to the weakest intensity of stimulus. The generalization gradient for the first group would have superimposed upon it a decreasing gradient of response to the more distant tones determined by the decreased intensity of stimulation *per se*. With the second group the gradient of response to intensity itself would operate in the reverse direction. Pooling of the responses to the conditioned stimuli, both weakest and strongest, and of the responses to the accessory stimuli enables one to determine the gradient of *intensity generalization* with the intensity effect *per se* held constant. Sound stimuli were used because of the precision of control which they permit. The extreme of intensity, either at the weak or at the strong end of the scale, paired with the unconditioned stimulus is labeled stimulus *O*. The three other intensities, 50 *j n d*'s apart, which were not presented during reinforcement, are designated as stimuli *1*, *2*, and *3*, respectively, in order of decreasing proximity to the conditioned intensity.

Had the loudness scale (Churcher 6, Stevens 24) been available at the time, it would undoubtedly have been more satisfactory to have used it. The generalization gradient obtained in the experiment would not have been greatly affected, however, since the counterbalanced groups made the distances equal determined from either extreme of intensity.

Fletcher (8) has provided precise data on the number of just perceptible differences in intensity of tones at various frequencies, and so his results were utilized. The frequency of the tone employed in the present experiment was 1000 cycles. At this frequency there are, according to Fletcher, 374 just perceptible differences in intensity between the threshold of audition and that of feeling. The intensities chosen for this experiment were taken at intervals of 50 just noticeable differences. The weakest tone was 40 decibels above threshold, the other intensities being 60, 74, and 86 decibels above threshold, respectively. The various intensities were obtained by the use of the accessory attenuation box.

Thirty-two undergraduate students, paid by the hour, were employed. They were unfamiliar with the process of conditioning. Four subjects were rejected because of unsatisfactory galvanic responses before the final group was selected.

A comparison of the responses to two presentations of the shock before conditioning shows that the two groups did not differ significantly. The first group had an average magnitude of response of 41.7 mm. of galvanic deflection, while the second averaged 40.3. The entire program of the experiment comprised three steps, of which the above control was the first.

I. *Test response to shock twice*
II. Give 16 paired presentations of shock and intensity *0*
III. Test response to intensities *0, 1, 2,* and *3* three times each (Cycles I, II, and III in Tables 1 and 2)

The test responses were taken in a prearranged permutational order to counterbalance extinctive effects and other variable factors.

RESULTS AND DISCUSSION

The results presented in Table 1 show the magnitudes of response to the conditioned stimulus and to the adjacent intensities during the three cycles of testing. Each cycle includes one test with each

TABLE 1

Magnitude of Response (in mm.) to Conditioned (*0*) and Adjacent Intensities of Tone, 50 (*1*), 100 (*2*), and 150 (*3*) j n d.'s Removed

Stimuli	Cycle I				Cycle II				Cycle III			
	0	*1*	*2*	*3*	*0*	*1*	*2*	*3*	*0*	*1*	*2*	*3*
					Group conditioned to 86 db tone							
Subjects												
I	7.0	4.1	8.4	3.4	16.0	9.0	5.4	6.6	13.1	7.8	6.8	4.0
II	15.7	19.0	9.8	8.2	20.1	10.8	10.7	14.9	20.4	10.7	10.7	12.2
III	12.2	14.9	9.4	14.4	10.3	9.2	5.7	7.7	20.8	13.8	8.8	7.3
IV	20.8	16.8	14.0	14.2	18.8	4.6	5.8	8.6	16.0	3.0	6.0	4.6
V	10.0	15.2	5.9	11.2	16.7	17.0	17.8	16.0	15.2	14.9	19.0	9.4
VI	10.5	9.5	8.6	7.5	19.0	11.7	10.6	13.7	11.8	11.8	13.7	10.5
VII	23.1	14.0	20.1	17.0	20.1	24.5	12.5	12.4	27.8	14.3	12.5	18.2
VIII	17.0	16.4	12.6	20.1	9.8	4.0	3.6	4.8	10.6	4.0	3.9	3.6
IX	13.8	17.8	12.2	5.3	25.2	12.3	15.0	3.3	18.9	5.2	5.8	6.3
X	22.5	17.7	15.9	6.9	23.6	20.3	20.8	8.0	16.1	7.8	9.2	5.1
XI	23.5	10.9	10.0	5.0	24.0	21.0	5.9	6.9	26.5	17.1	15.0	2.8
XII	17.1	22.2	16.3	12.9	22.5	17.8	14.1	8.7	29.0	27.5	18.7	14.5
XIII	18.8	20.1	15.3	18.1	17.4	12.4	8.3	1.9	25.0	22.7	13.5	12.5
XIV	16.4	12.1	9.6	5.3	15.6	10.7	8.4	3.3	19.3	10.2	11.1	9.1
XV	15.8	10.7	11.2	10.0	19.3	12.3	16.0	7.8	7.8	4.4	6.2	5.4
XVI	12.3	13.2	10.4	8.1	12.1	16.1	10.1	6.5	7.7	18.4	3.6	3.1
Mean	16.03	14.66	11.87	10.47	18.16	13.36	10.67	8.20	17.87	12.10	10.28	8.04
					Group conditioned to 40 db tone							
XVII	12.7	18.9	14.5	20.7	26.9	24.8	18.9	18.2	19.3	23.8	21.0	23.8
XVIII	7.9	7.2	11.5	12.4	6.3	5.6	10.0	15.0	24.0	17.0	14.2	14.0
XIX	7.7	10.0	10.0	8.1	6.6	10.3	9.5	22.9	6.0	11.0	13.0	11.7
XX	20.1	23.9	13.2	18.1	14.8	20.6	8.9	16.2	11.3	9.8	11.8	7.3
XXI	11.1	8.1	10.2	9.5	8.0	9.2	12.0	12.0	14.1	10.6	12.0	12.6
XXII	12.0	8.0	7.8	19.2	13.8	20.0	12.2	13.4	9.8	2.6	2.6	5.8
XXIII	10.1	21.3	22.3	26.6	3.2	5.6	12.4	13.6	5.0	6.9	9.0	10.6
XXIV	4.1	15.9	13.3	39.5	5.1	4.5	7.3	9.4	6.3	6.6	11.5	11.1
XXV	13.1	30.1	17.5	13.8	13.3	14.7	25.0	30.7	24.8	19.1	28.7	31.1
XXVI	12.1	32.0	29.5	31.1	6.9	21.5	23.9	22.0	2.5	12.0	15.7	22.2
XXVII	13.0	4.2	28.2	12.0	3.4	3.4	3.2	5.8	4.6	4.6	8.1	5.6
XXVIII	9.3	9.8	12.4	16.2	19.8	22.4	21.5	23.6	18.3	17.8	10.2	12.3
XXIX	10.8	11.2	13.6	12.9	22.7	23.8	24.7	29.2	7.8	10.2	8.3	10.0
XXX	7.6	8.3	10.4	8.8	8.9	10.0	13.6	17.1	10.1	9.6	11.4	11.6
XXXI	11.9	10.7	11.4	15.2	17.6	15.4	16.8	12.4	5.3	6.4	7.7	8.9
XXXII	17.6	8.2	14.2	6.4	8.6	7.9	22.1	16.1	6.2	7.5	18.1	9.1
Mean	11.32	14.24	15.06	16.91	11.62	13.73	15.12	17.35	10.96	10.97	12.71	12.99

of the four intensities. For convenience in discussion, the detailed records of Table 1 are summarized in Table 2

TABLE 2

SUMMARY TABLE

Magnitudes of galvanic response (in mm.) during successive cycles of the testing program to conditioned intensity (*0*) and adjacent intensities of tone, 50 (*1*), 100 (*2*), and 150 (*3*) *j.n.d.*'s removed
16 subjects in each group.

	Tonal stimuli			
	0	*1*	*2*	*3*
	Group conditioned to 86 db intensity			
Cycle I	16.03	14.66	11.87	10.47
Cycle II	18.16	13.36	10.67	8.20
Cycle III	17.87	12.10	10.28	8.04
	Group conditioned to 40 db intensity			
Cycle I	11.32	14.24	15.06	16.91
Cycle II	11.62	13.73	15.12	17.35
Cycle III	10.96	10.97	12.71	12.99
	Combined groups[4]			
Cycle I	13.67	14.45	13.46	13.69
Cycle II	14.89	13.54	12.89	12.78
Cycle III	14.41	11.53	11.49	10.51
Mean	14.31	13.17	12.62	12.32
PE_M	0.60	0.57	0.44	0.65

The mean responses for all of the subjects to the conditioned and adjacent intensities of sound for successive cycles of testing are shown graphically in Figure 1 In comparison with the gradient which was previously obtained for generalization of frequency (11), the type of gradient is much less steep for intensity, especially in view of the fact that the distances in *j.n.d.*'s between the stimuli were larger in the present study This outcome is perhaps to be expected in the light of such results as those of Upton (25) which demonstrated that continuous reinforcement of a given tone was accompanied by a high degree of differentiation with respect to frequency, but "that a generalized conditioned response to all available intensities of the conditioned frequency had been established" (p 421) The marked generalization found with the galvanic skin response has recently been commented upon by Campbell (5).

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[4] The data obtained from the two groups of subjects are pooled to eliminate the effect of intensity *per se.* This procedure is justifiable in the present case because the relationship between intensity and magnitude of response is essentially linear (See 14 and below)

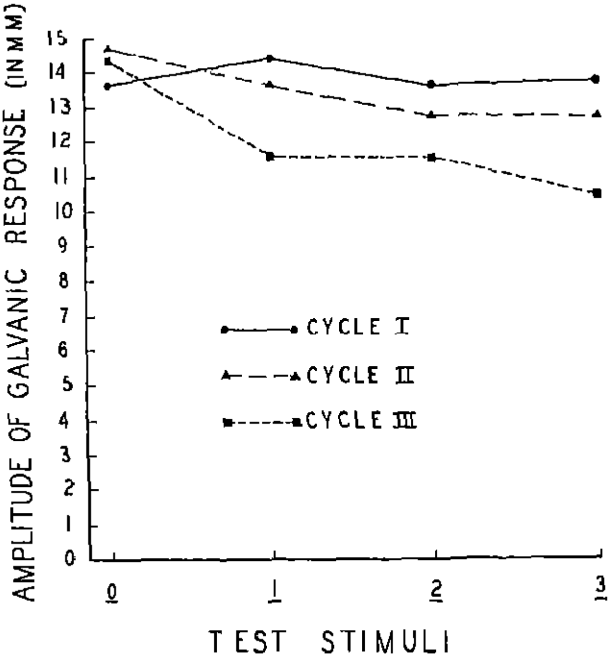

FIGURE 1

Generalization of Conditioned Excitatory Tendencies with Varying Intensities of Tone

Responses to conditioned intensity of tone (*0*) and to adjacent intensities of tone, 50 (*1*), 100 (*2*), and 150 (*3*) *j n d*'s removed, during successive cycles of testing

It will be observed from the results shown in Figure 1 that the average of the first responses to the conditioned intensity is smaller than the average of the responses to the novel intensities, but that with subsequent testing the response to the conditioned intensity increases. The writer (10) has suggested an explanation for this phenomenon based on "inhibition of reinforcement." Continuous reinforcement results in an adaptation to the conditioned stimulus-unconditioned stimulus combination. Pavlov (20) tersely states that an identical stimulus "applied at short intervals of time quickly diminishes in its effect" (p 248). This adaptation may be labeled for convenience "inhibition of reinforcement," since it displays the characteristics of other forms of "inhibition" described by Pavlov The omission of the unconditioned stimulus during testing, as well as the presentation of the novel stimuli, will produce "disinhibition," resulting in a larger response on the second test trial.

Quite marked in the present experiment, and much more pronounced in an accessory experiment on tactually conditioned responses, is the augmented size of the response to the intensity farthest removed from the conditioned stimulus on the first cycle of testing. Pavlov would call this phenomenon "induction." No satisfactory explanation is available at present. The experiment of Robinson (23) on the similarity factor in retroactive inhibition is recalled. Here he obtained a continuous decrease in efficiency of recall with decreasing similarity of original and interpolated material, but on the first cycle of testing in each phase of the study there was an upturn in the amount of recall when the material became completely dissimilar "Only in the first cycle do we find the inversion that is supposed to exist in the relationship between similarity and retroaction" (p 306) "Just how unfamiliarity with the mode of presentation should produce this inversion, which further practice obliterates, is not at all clear" (p. 308)[5]

Another interesting phenomenon observed is the differential rate of extinction of the conditioned and "generalized" responses The decline in the magnitude of the responses is very gradual. In the case of the subjects conditioned to the strong intensity of sound the average magnitude of response during the three cycles of testing even rises, presumably as a result of the operation of "inhibition of reinforcement" described above The generalized responses, on the other hand, appear to extinguish much more rapidly. It will be seen that the decrease in the size of the generalized responses is fairly regular, although there is no clear relationship between the degree of remoteness from the conditioned intensity and the rapidity of extinction. The slope of the gradient of generalization, determined by dividing the response to intensity *0* and *1* by that to *2* and *3*, changes from 1 03 on the first cycle to 1 18 on the third Further study of this problem has been made in another paper of the present series (12).

---

[5] The similarity in the manifestations of generalization and retroactive inhibition in a wide variety of situations suggests the possibility of integrating these two diverse fields of study by theoretical systematization, in much the same way that Lepley (17) and Hull (15) have bridged the gap between phenomena as seemingly unlike as trace conditioned reflexes and rote learning True integration of these two distinct aspects of learning would demand that relationships observed between variables in the first system would be paralleled by similar relationships in the second A large number of such parallels are obtained. Discussion of this problem is reserved for a later article with Eleanor J. Gibson, who is working on related experimental problems at present

One set of incidental results may be mentioned. If the magnitude of response is plotted against the intensity of stimulus used, whether the stimulus was used in the conditioning process or was presented for the first time in the test series, the results given in Table 3 are obtained These results are in agreement with the study of the writer (14) on the relationship between the intensity of the conditioned stimulus and the magnitude of the galvanic response, in showing a relatively linear relationship between intensity and response when the stimuli are separated by an equal number of just noticeable differences in intensity

TABLE 3
AVERAGE MAGNITUDE OF GALVANIC RESPONSE TO EACH OF THE FOUR INTENSITIES OF SOUND STIMULI

Decibels above threshold	40	60	74	86
Response (in mm.)	10.10	11 97	13 82	16.52

An adequate theoretical explanation of the generalization of intensity is difficult to make at present. It has already been pointed out that the theory of Pavlov, in terms of a cortical "spread," cannot cover this type of generalization How the factors of frequency of discharge, number of end-organs, activated adaptation-time, etc., involved in intensity discrimination affect the extent and nature of generalization we do not know.

Guthrie (9) has recently advanced a quite different theory to explain generalization:

> We have excellent reasons for believing that the conditions determining these two phenomena are not the obscure and speculative brain changes suggested by Pavlov, and that they will be found to depend on certain conditions more open to observation. We may first remark that the substitute stimulus of the laboratory record is probably not the actual conditioner
>
> The actual stimuli ..are movement-produced stimuli attend-

> ing on listening to the tone or on shifting position in response to touch The fact that cue and reflex can be separated by several minutes makes this even more probable
>
> If these movement-produced stimuli are the actual conditioners, the stimuli actually contiguous in time with the response, the phenomenon of generalization or irradiation is very simply explained. Listening to a different tone may involve listening movements so much like those called out by the practiced cue that these similar movements furnish the real conditioners of the action (pp 87-88).

This theory has much to recommend it. It is simple, based on straightforward physiological mechanisms, and applies as well to intensity variations as to frequency or spatial variations The theory is so phrased, however, as to be most difficult to demonstrate or disprove

SUMMARY

1. Generalization of intensity was studied with tonal stimuli Four tones spaced at 50 *j n d.*'s in intensity were employed. To hold constant the effect of intensity *per se,* one group of subjects was conditioned to the weakest intensity, while an equated group was conditioned to the strongest intensity of tone. Pooling of the two groups thus permitted the determination of the generalization gradient independently of the intensity effect *per se.*

2 The conditioned response was the galvanic skin reaction measured by the method of Tarchanoff The tones used as conditioned stimuli were presented for 400 milliseconds. The electric shock used as the unconditioned stimulus lasted 75 milliseconds The pause between conditioned and unconditioned stimuli was 95 milliseconds.

3 The gradient of generalization obtained shows the same general form as that for frequency generalization but is less steep Almost complete generalization with respect to intensity is indicated.

4 The strength of the conditioned response increases initially during testing, presumably as a result of the disinhibition of the "inhibition of reinforcement"

5 The data suggest a more rapid extinction rate of the generalized than of the conditioned responses.

6. The increase in magnitude of galvanic response with increased intensity of stimulation is almost linear when the stimuli

are separated by equal numbers of just noticeable differences in intensity

7. A large number of parallels in the phenomena of generalization and of retroactive inhibition suggest that the two fields may be integrated by theoretical analysis

8. The theory of generalization advanced by Pavlov is completely inadequate to cover intensity generalization. Guthrie's theory is simple and does cover this form of generalization, but is extremely difficult to test crucially.

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SURVEY OF EXPERIMENTS OF CHILDREN'S ATTITUDES TOWARD PARENTS 1894-1936*

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Children's attitudes toward parents have been occasional subjects of scientific interest and experimentation over a period of several decades. However, no systematic investigation of a comprehensive sort has been undertaken This deficiency is rather surprising in view of the large body of sociological, psychological, and psychoanalytic writings describing children's reactions to parental behavior and home atmosphere

The present survey of experimental literature was undertaken with the aim of determining what had been accomplished in the field of measuring children's attitudes by means of tests and questionnaires.

The following abstracts contain, in general, a brief description of the experimental procedures employed in the investigations and a statement of results obtained. Only those studies are included in which some measuring device (questionnaire, interview form or test blank) was employed for recording and scoring attitude responses.

THE INVESTIGATIONS

As early as 1894, Barnes (4), influenced by the work of G. Stanley Hall, analyzed the responses of 4,000 children (ages 7 to 16) who described punishments they had received. It was found that "children do not object to any of the ordinary forms of punishment because of the penalty itself." Children do object to unjust punishment—that is, punishment administered when the child feels that he was innocent of any wrongdoing or unable to avoid an accident, punishment administered without any reason being apparent to the child, and punishment which appears to be spiteful or unusual

The types of punishment advocated by 3,000 school children were analyzed by Schallenberger (23) Whipping, sending to bed, and confining are advocated with decreasing frequency from the age of

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six to sixteen; while explaining, excusing and threatening are mentioned with increasing frequency from the younger to the older ages. Boys are somewhat more severe than girls, and younger children are less merciful than older ones Young children judge actions by their results, while older ones look at the motives which prompt them

Goddard (8), using a questionnaire technique, found that German children differ considerably from American children in the greater frequency with which they choose parents as ideal men and women. Goddard (8), Darrah (7), Barnes (3), and Chambers (6) found that American, English, and German children choose parents less frequently as ideals as they progress from the age of seven to sixteen. Although boys seldom choose a woman as an ideal, a large percentage of American girls choose men as ideals, and the percentage increases with age

A questionnaire study made by Nimkoff (20) on 1,336 males and 1,336 females (with average age about 18 years) indicates that both sons and daughters give more willing and complete obedience to the mother than to the father, confide in the mother more often than the father, and are more willing to share recreational experiences with the mother than with the father Daughters, however, are more obedient, confiding and more frequent companions to their mothers than sons are.

Lynd and Lynd (15) made a questionnaire study of children's attitudes as a part of their investigation of the social structure of a typical American city The most frequent sources of disagreement between children and parents according to the replies of 348 boys and 382 girls are: hour of getting in at night, number of nights out during school week, spending money, use of automobile, and the boys and girls chosen as friends. High school boys and girls are closely agreed as to the relative desirability of certain traits in a father. Such traits as spending time with his children, respecting his children's opinions, and never nagging are rated as being more important than owning a good-looking car, being socially prominent, and being well dressed. Boys and girls are also closely agreed that, in a mother such traits as being a good cook and housekeeper, never nagging, and respecting children's opinions are more important than being prominent in social life, being well dressed, being a good hostess and being a college graduate

An extensive Child-Parent Relationships questionnaire was used by Bowers (5) with 1,168 high school and college students. The girls believe that they are favored by their fathers, and the boys that they are favored by their mothers. There is a preponderance of preference for the mother by boys and girls at all ages. The mother does a larger part (mother 54 per cent, father 31 per cent) of the punishing, "but whether the punishment is administered by the mother, the father, or by both parents, a preponderant percentage still prefers the mother." A large percentage (42 per cent) felt that they had been unjustly punished, and 45 per cent resented punishment. An average of 40 per cent of the children fear the father, and 19 per cent fear the mother, although the children come from the better class of home.

An interview study of parent preferences was made by Simpson (26). Her results, obtained with 500 children (ages five to nine), indicate that children of both sexes generally prefer the mother to the father, and preference for the father declines with the age of the child. According to the reasons which the children themselves give for their preferences, they like the parent best who caters to their physical wants, expresses affection for them, plays with them, and punishes them least.

In a questionnaire study of 40 delinquent and 40 non-delinquent boys, Reinhardt and Fowler (22) found that approximately twice as many of the delinquent boys regarded as the "meanest man" one who whips his children. Seventy per cent of the delinquent boys gave this response.

Meltzer (18) used a standard form for recording children's free association responses in an interview. One hundred fifty school children, 8 to 16 years of age, each gave 10 attitude responses toward each parent. "Reactions classified as very mildly or barely pleasant, added up to 65.5 per cent of all responses for mother and 61 per cent for father, unpleasant reactions, similarly subdivided according to intensity, totalled 4 per cent for mother and 7.6 per cent for father." Fathers are more frequently mentioned as the person who "takes me places," "gives me," and "plays with me!" Expressions of love, loyalty and relationship are more frequently mentioned regarding the mother. Sixty per cent of all responses indicate some form of dependence.

In a recent elaboration of this method, Meltzer (19) studied the association responses of children from three distinct socio-economic groups rich, middle class, and very poor. Children from the poorest and richest homes think of parents in terms of "personality characteristics," while "does things for me" is given most frequently as a characteristic of middle class parents Children from the lowest economic group give most reactions relating to "treatment and discipline" Middle class children give the largest number of "emotional acceptance" reactions, while lowest class children give the most "hostile" reactions Fear, guilt, and adoration reactions are given largely by children from the richest homes, shame reactions by the middle class, and ambivalent reactions by the poorest children. Attitudes signifying insecurity are found largely in children from the poorest homes. Both over-dependence and rejection attitudes are expressed by the rich children Middle class children regard parents as less repressive than do the other two groups

Using a standard interview form with 107 juvenile delinquents, Newell (21) found that 64 per cent of the boys and 56 per cent of the girls stated that their fathers did most of the punishing at home Fifty per cent of these children say they were punished more than any of their brothers and sisters. Preponderant percentages of these children preferred the parent of the opposite sex. Eighty per cent of the boys prefer the mother, and ten per cent the father; while only 33 per cent of the girls prefer the mother, and 53 per cent prefer the father. There is a definite tendency for jealousies to be felt toward siblings favored by the parents, particularly by the parent opposite in sex from the patient.

Analysis of the case records of 40 problem children (8 to 10 years old) by Yarnelle (37) indicates that boys prefer the mother, no matter what her attitude toward the child. Girls tended to prefer the parent who preferred or over-protected them or played the dominating rôle in the family "The boys who were over-protected by their mothers tended to have personality difficulties, while, to a less degree, those who were rejected displayed socially unacceptable behavior" The children who preferred the mother tended to prefer being alone to participating in group activity.

The Thurstone technique was employed by Stagner (27) in constructing two scales for measuring attitudes toward one's mother and father. Two groups of male college students, one emotionally stable, the other emotionally unstable responded. "It is indicated that emotionally unstable young men have decidedly less favorable attitudes toward their fathers and slightly more favorable attitudes toward their mothers" Stagner (28) also found that in the construction of his scale the mean values of the male sorters for the father and mother scales are identical, while women sorters favor their fathers.

A questionnaire study made by Stevens (29) comparing 100 adult recidivists with 100 college freshmen indicates that very strict home discipline and strict religious atmosphere in early life are associated with subsequent antisocial behavior Strict home atmosphere, parental incompatibility, and lack of parent-child comradeship were significantly more prevalent in the delinquent group

Watson (35) reports the results of a questionnaire which was rated by 230 graduate students in education. Those students who had been severely punished and were strictly supervised and overprotected as children found themselves suffering more serious personality maladjustments as adults than did those students whose parents treated them leniently in childhood

An elaborate questionnaire was employed by Woodward (36) in his investigation of the factors influencing the religious lives of 384 adults whose religious beliefs range from conservatism to atheism. Healthy-mindedness, rebellion against discipline, and friction between parents all show negative correlations with adult religious life Self-consciousness seems especially to follow strong maternal opposition, and to be accompanied by insecurity, habits of worry, and lack of friendships Friction between the parents is associated with the child's rebellion against parental discipline and with friction between siblings

Through the administration of a set of scales for measuring attitudes toward the behavior of parents and children, Stogdill (30, 31) found that there is a close correlation between the attitudes of college students and parents while psychologists are significantly more liberal in their viewpoint Subsequent studies (32, 33) reveal that students are somewhat more liberal than parents in granting children freedom from parental control Students who reported having been severely punished as children endorsed the strongest control, while those who resented punishment endorsed freedom from control.

Four hundred children from 4th grade elementary school to

4th year in college listed 1,695 advantages and 2,287 disadvantages from mothers' working regularly outside the home, in a study made by Mathews (16) The younger children's objections are based largely on the desire for physical comfort and protection; while with increase of age, social factors, such as standing of family in the community, became increasingly important. In a subsequent study, Matthews (17) used a "Home Blank" of 100 items asking questions of fact about the home and also whether the child was made happy or unhappy by these facts The subjects were 568 children, grades 5 to 9 Of these, 100 children were found whose mothers worked out of the home These were carefully paired with 100 children of non-working mothers, keeping constant age, grade, sex, school, father's occupation, and community The two groups differed more in socio-economic status than in attitude The slight differences in attitude found were in favor of the children of non-working mothers.

A questionnaire study made by Leonard (13) of 303 high school girls concerning mother-daughter relationships indicates that daughters are more likely to confide in the mother who is patient, sympathetic, and willing to accept a joint decision, and that a wholesome confidential relationship is hindered by such factors as emotionality in the mother (yelling, nagging, weeping, ridicule), or misunderstanding of the girl's attitude, actions or problems. Leonard (14) also used separate questionnaires with 203 freshman girls and their mothers in a study of mother-daughter relationships. A marked correlation was found between poor social adjustment in the girls and dreading to leave home, homesickness, mother's crying, desire on part of girl to return home or have the mother's comfort and presence at college There was found to be a positive relationship between a good social adjustment and smoking, more than one love affair, and understanding by the mother of her daughter's sex problems

Klein (11) had the questionnaire results of 70 men students rated by three judges to determine the degree of "father antagonism" experienced by these individuals. A correlation of 0 60 was found between father antagonism and radicalism scores made on a questionnaire on public issues.

Similar results are reported by Allport (1), who found that radical college students disagree with their fathers in political opinions far more frequently than do conservative students

Harris, Remmers, and Ellison (9) used Harper's "Social Study" questionnaire with 307 college undergraduates Both men and women students who disagree with their fathers' politics are more liberal in their social attitudes than are the students who agree with their fathers

Telford (34) used Thurstone's scale for the measurement of attitudes toward the treatment of criminals Of 160 students who stated the religious affiliations of their parents, 24 cases were found where the father, mother and child did not belong to the same church The 24 students in this group were more liberal in their attitudes than the average for the group as a whole In cases where father and mother belong to different denominations, the mother is more dominant in determining the church membership of the children.

A questionnaire study made by Anderson and Dvorak (2) with 30 students as subjects revealed that "college students differ from their parents and grandparents on the standards on which they base their conduct, in that they prefer the standard of prudence and esthetics to that of right and wrong The greatest differences in standards of conduct occur between age groups rather than between sex groups" Students differ from grandparents and parents more than parents and grandparents differ

Shuttleworth and May (25) used three check lists of attitudes toward home and parents in their comparative study of the attitudes of children who attend movies frequently and those who attend rarely or not at all. The slight differences found in attitudes toward parents indicate that "movie children are more discriminating and more sensitive to parental approvals and disapprovals."

The attitudes of 4,000 high school pupils were measured by Kulp and Davidson (12) on an International Attitude test. The group studied included 91 pairs of brothers, 85 pairs of sisters, 155 pairs of brothers and sisters, making a total of 331 pairs. The results indicate that the "resemblance of siblings in social attitudes can be measured by a correlation coefficient of about 0 32 and resemblance of random pairs can be measured by a coefficient of about 0.00." Sisters, probably because they are more closely supervised by the home, show a somewhat closer resemblance in attitudes than brothers do

Another study indicates that children resemble their parents in moral standards more closely than any one else Hartshorne, May, and Shuttleworth (10) compared children's scores on a moral knowledge test with the scores of other persons with whom they were closely associated The following correlation coefficients were obtained. children with parents .545; children with friends .353; children with club leaders 137, children with school teachers .060; children with Sunday school teachers .002

Sherman (24) has made a study of factors influencing the development of attitudes of children living in four more or less isolated mountain communities It is apparent from his data that the lower the status of the community in the scale of social development the more nearly does the general behavior simulate the expressed attitudes Children in the more isolated communities do not change their attitudes for the purpose of winning adult approval or making a good impression as readily as do children in communities of higher social development.

SUMMARY

The results of these studies may be summarized as follows

1 Children feel a high degree of dependence on their parents (18); although they become less dependent on parents, and choose parents less frequently as ideals as they advance in age from six to sixteen (3, 6, 7, 8).

2. The mother is preferred to the father as a parent by unselected school children of both sexes (5, 18, 20, 26, 37); while delinquent and problem children are likely to prefer the parent of the opposite sex, especially if that parent is over-protective (27, 37)

3. Preferences for parents are formed largely on a "value received" basis, especially by younger children Older children give more sophisticated reasons for their preferences (16, 17, 18, 26). Children feel that parents tend to prefer offspring of the opposite sex (5, 20).

4. Children resent severe and unjust discipline (4, 5, 21, 22, 23), and prefer greater freedom from control and supervision than parents consider desirable (15, 32, 33) Child guidance specialists are even more insistent than children upon the desirability of freedom from too strict parental control (30, 31, 32, 33).

5. Very strict discipline and strict religion in the early home

life of the child may be associated with later personality maladjustments, delinquencies, or unhappiness On the other hand, children who come from homes where discipline and religious attitudes are lax are more likely to be happy and well adjusted (13, 14, 29, 35, 36, 37).

6. Young people who feel a certain amount of antagonism toward their parents or who disagree with their parents are likely to be liberal in their attitudes on social and moral questions (1, 2, 9, 11, 34).

7 There is evidence that children's attitudes and behavior are highly determined by the nature and complexity of the social environment in which they are reared (24) Parental and family influences are more potent than such factors as intelligence and socio-economic status in determining children's attitudes (10, 12, 33), although social status may be a conditioning factor (19).

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PERSONALITY TESTS OF DEAF ADULTS*[1]

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INTRODUCTION

It is often held that physical handicaps leave their imprint on the emotional life of the individual This is considered to be particularly true in the case of deafness as the auditory defect tends to restrict the range of experience and to isolate the individual so affected from ready social relations with the normal hearing. Moreover, persons who have been without hearing from early childhood frequently suffer also from a marked language handicap since the most important avenue of verbal communication is closed to them. Their vocabulary is often meager and their comprehension of the written word restricted. All of these factors are likely to influence the personality adjustments of the deaf.

Objective studies of the personality adjustments of adults suffering from different degrees of hearing loss are few in number.

Welles (4) administered the Bernreuter *Personality Inventory* to 225 urban hard-of-hearing adults and compared the scores with those of comparable normal hearing subjects. He found the hypacousic group to be significantly more emotional, more introverted and less dominant than the hearing control group. There was no marked difference between the two groups in self-sufficiency.

Pintner (3) studied emotional stability among rural hard-of-hearing groups by means of the Bernreuter *Inventory* and made comparisons with results from equivalent normal hearing subjects. The hypacousic group proved to be decidedly more neurotic, more introverted and more submissive than its control hearing group In addition, the hard-of-hearing scored as more self-sufficient

Somewhat similar results were obtained by Lyon (2) in his study of deaf high school pupils. On the basis of the Thurstone *Person-*

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ality Schedule, the percentage of deaf high school pupils classified as emotionally maladjusted was found to be twice that of college freshmen of corresponding age.

The Problem

The present study is concerned with some personality adjustments of deaf adults, as indicated by their scores on the Bernreuter *Personality Inventory,* in comparison with norms for the hearing and in relation to several personal factors.

Try-out of the Bernreuter Inventory on Deaf College Students

To ascertain whether the Bernreuter Test would serve as a valid measure of the personality adjustments of the deaf, the inventory was tried out on 50 deaf students in attendance at Gallaudet College. Six faculty members rated the students, with whom they were acquainted, on a nine-point scale in the traits included on the test, i e., neurotic tendency, self-sufficiency, introversion and dominance Correlations between Bernreuter scores and the ratings of college students are shown in Table 1.

TABLE 1

Correlations between Bernreuter Scores and Instructors' Ratings of Gallaudet College Students in Neurotic Tendency (B1-N), Self-Sufficiency (B2-S), Introversion (B3-I) and Dominance (B4-D)

Rater	B1-N	B2-S	B3-I	B4-D	No of Cases
B	11±.11	18± 10	.28± 10	62± 07	42
D	.19±.09	17± 09	34± 09	.495± 08	46
H	16±.09	35± 09	— 07±.10	44± 08	46
K	—.15±.10	28± 09	— 06± 10	33± 09	46
N	— 11±.11	53±.08	.27±.10	49±.08	43
R	12±.11	25±.10	—.39± 10	.48±.08	39
Mean rating	— 07± 10	43± 08	14±.10	55± 07	46

Whereas practically no correlation occurs between ratings and test scores in the areas of neurotic tendency and introversion, the agreement in self-sufficiency and dominance is fairly close It may be that the traits termed self-sufficiency and dominance were more easily identified by the raters than were neurotic tendency and introversion, or it may be that the latter two traits were not adequately measured in deaf subjects by the Bernreuter *Inventory* In view of the relatively low correlation coefficients usually obtained between personality test scores and ratings, it would appear that the Bernreuter Test measures in deaf subjects to some extent in two traits characteristic modes of adjustment which are visible to outside observers

Revision of the Bernreuter Inventory

The college students to whom the Bernreuter Test was administered constitute a selected group with respect to educational status and comprehension of English. The aim now was to reword the inventory so as to make it comprehensible to a more inclusive population of deaf adults without thereby altering the original significance of the test questions With this end in view, items which contained involved idioms or difficult sentence constructions were simplified.

Since, in spite of precautions, some changes in meaning might have occurred in the process of altering statements, a check was made of *responses to the simplified items For this purpose, the revised* Bernreuter Test was given to 27 normal hearing college students who had several weeks previously answered the Bernreuter Test in its original form

Scores obtained for each student from the original and revised forms of the Bernreuter were correlated As may be seen in Table 2,

TABLE 2

Retest Reliability Coefficients on the Bernreuter Inventory

	r between original and revised form N = 27	Retest reliability (Lentz) N = 139
B1-N	78	.92
B2-S	78	91
B3-I	78	90
B4-D	85	92

these retest coefficients are somewhat lower than the ones found by Lentz (1) from administering the Bernreuter to 139 students twice after a lapse of time varying from one to four weeks

Note was also made of the consistency with which subjects responded on the first and second tests to 44 of the items in which revisions had been made and to 44 items in which no changes had been made. The altered items were grouped under two headings; the first contained 25 slightly changed statements in which only one or two words had been altered, the second consisted of the 19 more extensively changed items involving modifications of sentence structure or substitutions of phrases.

The responses to each of these items on the original and the revised forms of the Bernreuter as given by the 27 students, were tabulated

In unchanged and slightly revised items, an average of six changes in response per item was made by the 27 students from the first to the second test, whereas responses to the 19 more extensively modified statements averaged eight changed responses per item The range in the number of changed responses per item by the 27 students extends from one to 14 for unchanged items, from one to 11 for slightly revised items, and from four to 12 for items in which more extensive revisions had been made

TABLE 3

MEAN RAW SCORE OF DEAF ADULT MEN ON THE FIRST REVISION OF THE BERNREUTER TEST ON THE BASIS OF ASSIGNED RATINGS

Test area and rating	Deaf adult men Number	Mean
Neurotic Tendency (B1-N)		
Very Well Balanced	5	—114
Well Balanced	15	—58
Average	4	—104
Fairly Well Balanced	2	+11
Somewhat Unstable	2	—57
Self Sufficiency (B2-S)		
Definitely Self Sufficient	4	+83
Rather Self Sufficient	9	+58
About Average	11	+34
Dependent	4	+8
Introversion (B3-I)		
Very Extroverted	1	—78
Somewhat Extroverted	5	—59
About Average	10	—33
Somewhat Introverted	5	—12
Quite Introverted	7	—21
Dominance (B4-D)		
Rather Dominant	6	+89
About Average	9	+63
Rather Submissive	11	+40
Very Submissive	2	+2

Since students responded in general with similar consistency to the unchanged and the slightly changed items on the revised form of the Bernreuter Test, indications are that the validity of items was not perceptibly affected by a slight revision Even among the 19 more extensively reworded items, there is an average increase of but two changes per item over the unchanged and slightly changed items.

The validity of the revised Bernreuter *Inventory* is demonstrated also in the essential agreement between ratings by one of the writers of deaf adult subjects known to him and test scores in the corresponding areas of the Bernreuter *Inventory* These results are given in Table 3. Because of the small number of women for whom ratings were available, data for this group are not included

Table 3 lists the ratings employed for each trait, the number of men receiving a given rating, and the mean score of that particular group As in the case of deaf students, the ratings and scores of deaf adults agree closely in the areas of self-sufficiency and dominance and somewhat less so in the area of introversion The lack of agreement between ratings and scores of neurotic tendency suggests that this trait is not so easily recognized by raters as the other three traits.

ADMINISTRATION OF THE FIRST REVISION OF THE BERNREUTER INVENTORY

The 71 deaf subjects on whom this revision of the *Inventory* was tried out, were located in widely scattered parts of the United States. They were reached with the coöperation of a number of capable deaf key persons known to one of the writers The key persons filled in test blanks themselves and then administered the inventory to deaf members of their community, giving them any help required to understand the meaning of items. In order to insure uniformity of procedure, detailed directions for administering the inventory were given to each key person. Instructions were also given to record difficult words and ambiguous phrases, and to suggest needed modifications in language and test procedure The completed test papers were returned by the subjects to their respective key persons, who in turn mailed them to one of the writers.

PREPARATION AND ADMINISTRATION OF THE FINAL REVISION OF THE BERNREUTER INVENTORY

The critical suggestions growing out of the experience of giving the Bernreuter Test to deaf subjects became the basis for the second revision of the inventory for use with the deaf. Changes made included the simplification of some items and a rephrasing of others to have them conform more closely to their original form. The one marked departure from the original form involved the sub-division of items 24, 28, 54, 87, 94 and 118 into two parts each, sub-item *A* permitting the subject to report on his behavior in a given situation if hearing persons were numerically predominant in it, sub-item *B* if deaf persons were involved (Items in which this change was made are given later on in this article.)

In the scoring of these double response items, both the *A* and *B* answers of each item were taken into consideration The weights assigned by the Bernreuter scoring key were given to each of the two responses and the value of the item as a whole determined by obtaining an average of the two scoring weights.

The statement of the subject's name was made optional, being required only of those who wished to be informed of their standing on the test. It developed that among the 126 subjects who answered the second revision, there were but 8 anonymous replies, five of them being from men and three from women.

Copies of the second revision of the Bernreuter Test were distributed again among deaf persons in all parts of the United States with the aid of key persons In order to keep their replies confidential, the subjects were given stamped and addressed envelopes with the instruction to return their test blanks directly to the writers. The attempt was made to reach a representative cross-section of deaf adults with respect to locality and social-economic status

COMPARISON OF SCORES FROM THE DEAF WITH NORMS FOR THE HEARING

The test results from the administration of the original form of the Bernreuter *Inventory* to 50 deaf college students and of the second revision of 126 deaf adults are presented in Table 4 The mean and standard deviation of raw scores are indicated for each group followed by the percentile norms for the respective popula-

TABLE 4

BERNREUTER INVENTORY SCORE OF DEAF STUDENTS AND DEAF ADULTS

Test area and group	Deaf students[1] Raw score Mean	Deaf students[1] Raw score S D	Original test form Hearing percentile equivalent	Deaf adults[2] Raw score Mean	Deaf adults[2] Raw score S D	Revised test form Hearing percentile equivalent
B1-N						
Men	—50.50	60.34	58	—46.98	74.92	61
Women	— 2.00	80.34	70	— 8.30	62.58	60
B2-S						
Men	+16.50	60.69	43	+25.94	54.12	43
Women	+ 2.00	52.64	47	+ 6.78	56.28	54
B3-I:						
Men	—21.33	38.25	56	—21.18	46.22	57
Women	+ 0.50	44.21	62	— 0.58	39.82	63
B4-D						
Men	+36.50	53.80	44	+48.56	54.72	45
Women	+29.00	68.26	48	+12.10	51.74	48

[1] Deaf Students include 30 men and 20 women

[2] Deaf Adults include 69 men and 57 women

tion as given by Bernreuter These percentile norms, based on the scores of normal hearing subjects, indicate how the average scores of deaf college students and deaf adults compare with the median standing of normal hearing college and adult groups.

In terms of hearing norms on the B1-N Test, the deaf of both sexes and both age groups score as emotionally more unstable than the hearing.

On the B2-S measure of self-sufficiency, the college population of both sexes and the adult men score below the median score of the hearing norms. In contrast, women of the deaf adult group average scores in self-sufficiency that place them above the median of the hearing norms Deaf men students score farther below the median percentile of hearing college men than do deaf women students below the median percentile of hearing college women.

On the B3-I test, the deaf of both groups and of both sexes average above the median of the hearing in introversion. Deaf women in comparison with hearing women score as more introverted than do deaf men in comparison with hearing men

With respect to the B4-D test, all groups of deaf score slightly below the median of the hearing in dominance On the basis of hearing norms, deaf men score as slightly less dominant than deaf women.

The scores for the young deaf college students and for the older deaf adults are in general very similar, in spite of the differences in the form of the test itself and in the ages of the two groups.

A summary of these results shows that the deaf in comparison with the hearing obtain scores indicative of greater emotional instability, more pronounced introversion, and a lesser degree of dominance Except for the deaf adult women who score slightly above the median of normal hearing women in self-sufficiency, the other deaf groups score as less self-sufficient than their equivalent normal hearing groups.

In this connection it is of interest to compare the deaf not only with the normal hearing, but also with the hypacousic for whom Pintner (3) and Welles (4) obtained data on the Bernreuter Test. The hypacousic groups consist almost wholly of women, therefore deaf men cannot be included in the comparison. Table 5 lists the mean Bernreuter scores and the equivalent hearing percentile scores of deaf college and adult women and of urban and rural hypacousic

TABLE 5

COMPARISON OF VARIOUS HYPACOUSIC GROUPS[1]

		B1-N		B2-S		B3-I		B4-D	
	N	Mean	Hearing percentile	Mean	Hearing percentile	Mean	Hearing percentile	Mean	Hearing percentile
Deaf Students—Women	20	− 2.0	70	+ 2.0	47	+ 0.5	62	+29.0	48
Deaf Adults—Women	57	− 8.3	60	+ 6.8	54	− 0.6	63	+12.1	48
Hypacousic Group Urban—Welles	196	−13.1	57	+17.1	60	+ 2.3	66	+11.1	47
Hypacousic Group Rural—Pintner	94	+13.6	69	+20.4	62	+12.4	74	−15.4	30
Total Hypacousic Group	290	− 4.7	66	+18.1	61	+ 5.3	68	+ 2.5	41

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[1] Test scores of hypacousic groups from Pintner, R., "Emotional Stability of the Hard of Hearing," *J Genet Psychol*, 1933, **43**, p 302, Table 4

women The total hypacousic group includes the rural and urban cases.

The deaf adults of the present study are for the most part an urban group. When compared with the urban hypacousic women, they are less self-sufficient, somewhat more neurotic, and slightly less introverted than the hypacousic There are practically no differences in dominance.

In comparison with the rural and total hypacousic groups, deaf students score as somewhat more neurotic and deaf adults as less neurotic Both groups of the deaf are less self-sufficient, less introverted, and more dominant than either the rural or the total hypacousic groups

But notwithstanding some slight differences between the scores of the deaf and the hypacousic, both of these groups deviate in a similar direction from the norms of the hearing The one exception to this occurs in self-sufficiency, deaf students scoring slightly below the median, whereas deaf adults and hypacousic adults score slightly above the median of the normal hearing In the other areas, the hypacousic and the deaf are in comparison with the normal hearing more neurotic, more introverted, and less dominant.

PERSONALITY SCORE IN RELATION TO AGE AND OTHER FACTORS

A personal data sheet, attached to each test paper and filled in by deaf subjects, supplied information about chronological age, age at becoming deaf, number of years spent in school, and other factors

Correlation coefficients were computed between Bernreuter scores and those variables on the personal data sheet which lent themselves to this form of statistical treatment The results are given in Table 6. Because of the relatively small number of deaf college students from whom personal data were obtained, the scores of men and women students were combined for the computation of correlation coefficients. Since differences in score due to sex are usually found on personality tests, the influence of this factor was eliminated by transmuting the scores of the students into the equivalent percentile scores for college men and women given by Bernreuter For the adult group, separate correlations were computed for men and women, and were based on raw scores.

The relationship between age in years and test score is too slight

TABLE 6

EEN BERNREUTER AND CHARACTERISTICS OF DEAF SUBJECTS

	Variables Correlated With Bernreuter Scores		
	Age in years	Age at becoming deaf	Amount of Schooling in years
	+.17± 10	— 33± 10	
ı	— 22± 08	— 28± 07	—.07±.08
nen	— 11± 09	— 06± 09	— 46± 07
	— 29± 10	+ 55±.07	
ı	+.10± 08	+ 49± 06	—.11± 08
nen	+ 02± 09	+ 32± 08	— 16±.09
	+ 14± 10	—.19± 10	
ı	— 18± 08	—.28± 07	— 03± 08
men	— 04± 09	— 24± 09	— 28± 08
	— 15± 10	+ 41± 09	
ı	+ 17± 08	+.35±.07	— 03± 08
men	+.11± 09	+ 20±.09	— 32±.08

ıdicate a reliable association. Nevertheless, the con-
in sign for adults and students may be of signifi-
udent group, the more desirable tendencies, that is
f neurotic tendency and introversion, together with
of self-sufficiency and dominance tend to go with
n the adult group this relationship is reversed—the
of the group particularly among men, score as less
ıoverted, and as more self-sufficient and dominant
members.

f the data suggests that these slight relationships be-
est score may be due to an unequal selection of cases
levels rather than to a fundamental relationship be-
core. Thus, the age range of the college group ex-
28 years The six oldest students ranging from 25
age tend to have relatively high scores in neurotic
roversion, and relatively low scores in self-sufficiency
Among adult men, the five oldest are from 55 to 64
hese five individuals, in comparison with the total

group of adult men, score below the mean in introversion and neurotic tendency and above the mean in dominance With but one exception, they score above the mean also in self-sufficiency The presence of these relatively unusual individuals in each of the two groups seems to account for the slight relationships found between age and Bernreuter score.

The correlations between test score and age at which the subject became deaf are somewhat larger. There is a slight tendency for a greater amount of neurotic tendency and introversion to be associated with earlier age at becoming deaf, and for lower scores in neurotic tendency and introversion to go with later age at becoming deaf. The opposite is true in the traits of self-sufficiency and dominance. The later in life subjects lost their hearing, the more self-sufficient and dominant are they now, whereas subjects deaf at an earlier age are less self-sufficient and dominant. The relationship between age at growing deaf and the traits of neurotic tendency, self-sufficiency and dominance is closest for the college group, next highest for adult men, and least marked for adult women

A statistical analysis indicates that these relationships are linear We may conclude from this that subjects, particularly men, who are deaf since early childhood are likely to be less well adjusted and less self-sufficient and dominant than individuals who lose their hearing at a relatively later age in life As the study includes no data for individuals who became deaf after the age of eighteen years, it is not possible to say what the relationship between adjustment and age at becoming deaf would be for such persons.

In the study of relationships between inventory score and number of years in school, the college students were omitted as their education is still in progress, and no final measure of that factor is therefore available. Among deaf adults, relationships between education and score are closer for women than for men. For men, most of the relationships, although consistently negative, are very slight. Since men and women are roughly equal in chronological age and number of years of school attendance, the implications are not quite clear as to why there should be a more marked tendency among women than among men for more years of schooling to go with better emotional stability, less introversion, and lesser amounts of self-sufficiency and dominance

PERSONALITY SCORE IN RELATION TO METHODS OF COMMUNICATION WITH THE HEARING

The deaf adults were next classified on the basis of their self-reported most frequent method of communicating with the hearing

To the question "How do you communicate with hearing persons?" 36 per cent of men and 32 per cent of women reply that they depend for the most part on speech, 28 per cent of men and 38 per cent of women place the emphasis on speech combined with writing, and 36 per cent of men and 30 per cent of women indicate writing to be their most frequent mode of communication The scores of the four men and one woman who reported communicating with the hearing by manual alphabet or signs in combination with various other methods are not included in these comparisons, as the small number of cases and the wide range of scores precluded the drawing of any reliable conclusions.

Table 7 lists the number of cases and the average score of subjects included in each of the classifications The last column of the table gives the significance of the difference between the mean scores of subjects in different classifications in terms of the ratio of the difference between the mean scores of two groups to the standard error of the difference A ratio of three or more is generally held to indicate a statistically reliable difference.

It will be seen that men and women who communicate with hearing persons by speech score as emotionally better adjusted and more extroverted than subjects who employ a combination of speech and writing The latter in turn are better adjusted than subjects who report that they use writing alone.

A similar difference among these groups is shown with respect to self-sufficiency and dominance Subjects employing speech score as more self-sufficient and dominant than individuals communicating with the hearing by speech and writing, whereas the subjects employing writing as their sole method of communication average the lowest scores in self-sufficiency and dominance In all four areas the difference in score is largest between subjects depending on speech alone for communicating with the hearing and subjects who resort to writing. The difference in score between these two groups is statistically reliable as applied to men in neurotic tendency, self-sufficiency

TABLE 7

COMPARISON OF PERSONALITY TEST SCORE OF SUBJECTS COMMUNICATING WITH HEARING PEOPLE BY SPEECH, BY SPEECH AND WRITING, AND BY WRITING RESPECTIVELY

Test area	Group	Method of communication	N	Mean	S D.	Groups compared	$\frac{\text{Diff}}{\text{S D}_{diff}}$
B1-N							
		Men:					
	1	Speech	23	—84.37	65.70	1 with 2	—2.58
	2	Speech & Writing	18	—25.78	76.89	1 with 3	—3.37
	3	Writing	23	—19.26	65.42	2 with 3	—.29
		Women:					
	1	Speech	17	—38.56	37.56	1 with 2	—1.61
	2	Speech & Writing	20	—10.70	65.95	1 with 3	—4.49
	3	Writing	16	31.32	50.49	2 with 3	—2.16
B2-S							
		Men					
	1	Speech	23	56.52	50.96	1 with 2	1.89
	2	Speech & Writing	18	29.89	39.21	1 with 3	3.37
	3	Writing	23	8.91	44.71	2 with 3	1.60
		Women:					
	1	Speech	17	22.00	66.49	1 with 2	.96
	2	Speech & Writing	20	4.40	38.66	1 with 3	2.25
	3	Writing	16	—22.00	43.99	2 with 3	1.89
B3-I							
		Men					
	1	Speech	23	—38.72	44.88	1 with 2	—1.96
	2	Speech &Writing	18	—10.34	46.82	1 with 3	—2.55
	3	Writing	23	— 6.00	42.00	2 with 3	— .31
		Women:					
	1	Speech	17	—20.18	20.20	1 with 2	—1.41
	2	Speech & Writing	20	— 5.00	42.85	1 with 3	—4.61
	3	Writing	16	26.44	35.35	2 with 3	—2.41
B4-D							
		Men					
	1	Speech	23	78.43	41.96	1 with 2	2.70
	2	Speech & Writing	18	39.00	49.52	1 with 3	4.09
	3	Writing	23	20.20	53.87	2 with 3	1.16
		Women					
	1	Speech	17	24.80	45.37	1 with 2	1.26
	2	Speech & Writing	20	3.50	57.40	1 with 3	2.11
	3	Writing	16	— 2.56	27.52	2 with 3	.42

and dominance, and with regard to women in neurotic tendency and self-sufficiency The scores of subjects who use both speech and writing to communicate with the hearing fall between these two extremes.

These findings give rise to the question whether training in speech *has produced behavior traits leading to relatively low* scores in neurotic tendency and introversion and to high scores in self-sufficiency and dominance, or whether persons possessing these traits are more likely to put their speech training to use. A scrutiny of the data suggests that the speech group, particularly among men, has had a somewhat greater advantage in acquiring speech than the group depending primarily on methods other than speech to communicate with the hearing Differences in the mean chronological age of subjects employing the various methods of communication are for the most part slight and not consistent. The average age of becoming deaf, however, is definitely higher for the groups employing speech or speech and writing than for the group depending on writing alone Thus, the average age at becoming deaf for the men of the speech group is nine years and for the women seven years. In the group which communicates with the hearing by a combination of speech and writing, the average age at becoming deaf is six years for men and ten for women, whereas it is two and three years respectively for the men and women of the writing group. This writing group, therefore, has never learned language in a natural manner in childhood. The majority is made up of those who were born deaf, and their personality traits may be influenced by this factor.

With regard to educational status, differences among the groups of men and women are less consistent. Among men, 83 per cent of the speech group, 50 per cent of the speech and writing group, and 39 per cent of the writing group have been to college. Of the women, 47 per cent of the speech group, 50 per cent of the speech and writing group, and 63 per cent of the writing group have been to college. Hence there is a greater tendency to employ speech on the part of those men who have attended college than those who have not The reverse is true for women, a slightly greater proportion of those who employ writing have attended college than those who employ speech and writing or speech alone

It appears then that the deaf subjects who communicate with the hearing by speech or by speech and writing obtain not only better scores on the personality inventory than subjects who employ writing, but also they have lost their hearing considerably later in life.

In response to the question "How do hearing people communicate with you?" 18 per cent of men respond with "speech," 41 per cent with "speech and writing," and the remaining 41 per cent with "writing." Of the women 29 per cent state that hearing people communicate with them by speech, 40 per cent report speech combined with writing, and the remaining 31 per cent report writing. Eight men and five women mention the manual alphabet or signs in various combinations with other methods. Their scores extend over a wide range, but in view of their small number the statistical results for them have not been included.

A similar tendency in the mean scores of these groups may be observed here (Table 8) as in the scores of subjects classified on the basis of their method of communicating with the hearing. Subjects with whom the hearing are reported to communicate by speech, score on the average as emotionally better adjusted, as less introverted, and as more dominant and more self-sufficient than subjects with whom the hearing communicate by writing either entirely or in part.

It will be noticed, however, that this tendency is in general more clear cut for men than for women. Deaf men who report that the hearing communicate with them by speech average consistently better scores than subjects with whom the hearing communicate by speech and writing, and they in turn have higher average scores than the men with whom the hearing communicate by writing alone. Among women, the differences between contrasted groups are found with but two exceptions in a similar direction. A higher average score in self-sufficiency is obtained by the group with whom the hearing communicate by speech and writing than by the group depending on speech only. Likewise, the group of women depending on writing only, scores slightly higher in dominance than the group resorting to speech and writing.

The question "Do you regard making friends with hearing people —easy, fairly hard, or very hard?" was included on the personal data sheet, in view of the commonly mentioned difficulty of the deaf

TABLE 8

Comparison of Personality Test Score of Subjects on the Basis of Method of Communication Employed with Them by Hearing Persons

Test area	Group	Method of communication	N	Mean	S.D.	Groups compared	$\frac{\text{Diff}}{\text{S.D.}_{diff}}$
B1-N							
		Men					
	1	Speech	10	—91.90	55.07	1 with 2	—2.45
	2	Speech & Writing	22	—35.23	71.27	1 with 3	—2.77
	3	Writing	22	—27.55	71.81	2 with 3	—.36
		Women					
	1	Speech	13	—27.88	36.02	1 with 2	—.85
	2	Speech & Writing	18	—13.67	56.35	1 with 3	—2.95
	3	Writing	14	25.93	57.17	2 with 3	—1.90
B2-S							
		Men					
	1	Speech	10	60.90	41.74	1 with 2	1.93
	2	Speech & Writing	22	30.27	41.47	1 with 3	2.82
	3	Writing	22	14.27	46.62	2 with 3	1.20
		Women					
	1	Speech	13	2.00	56.43	1 with 2	—.52
	2	Speech & Writing	18	12.50	54.41	1 with 3	.61
	3	Writing	14	—10.86	52.12	2 with 3	1.23
B3-I							
		Men					
	1	Speech	10	—49.60	33.32	1 with 2	—2.48
	2	Speech & Writing	22	—13.64	46.63	1 with 3	—2.78
	3	Writing	22	—10.37	44.13	2 with 3	—.24
		Women					
	1	Speech	13	—15.23	19.30	1 with 2	.75
	2	Speech & Writing	18	— 8.33	31.86	1 with 3	—3.28
	3	Writing	14	23.50	39.40	2 with 3	2.46
B4-D							
		Men:					
	1	Speech	10	86.20	39.07	1 with 2	2.73
	2	Speech & Writing	22	43.32	45.48	1 with 3	3.41
	3	Writing	22	28.18	54.86	2 with 3	.99
		Women:					
	1	Speech	13	15.73	41.97	1 with 2	.85
	2	Speech & Writing	18	1.11	53.94	1 with 3	.85
	3	Writing	14	4.00	28.05	2 with 3	—.20

to establish and maintain enjoyable social relations with the hearing. Only a small number of cases respond with the reply "very hard." As the inventory scores of this group do not differ to any noticeable extent from the scores of the group responding with "fairly hard," the subjects of these two groups were combined and their mean scores compared with scores of the group responding with "easy." Fifty-five per cent of the men report making friends with the hearing as easy and 45 per cent as fairly hard or very hard. Women are equally divided in these two groups. The mean scores of each of the groups and the difference between them in the four test areas are shown in Table 9.

TABLE 9

COMPARISON OF PERSONALITY TEST SCORE OF SUBJECTS ON THE BASIS OF REPORTED EASE OF MAKING FRIENDS WITH HEARING PEOPLE

Test area	Group	Making friends with hearing people Easy N	 Mean	 S.D.	 Hard N	 Mean	 S.D.	Diff. S.D. $_{diff.}$
B1-N								
	Men	38	—64.32	77.25	31	—32.56	65.35	—1.85
	Women	28	—18.14	49.41	28	4.25	66.61	—1.43
B2-S								
	Men	38	45.47	49.08	31	11.50	48.80	2.87
	Women	28	9.64	60.75	28	— 53	44.30	72
B3-I								
	Men	38	—28.06	47.38	31	—14.34	43.06	—1.26
	Women	28	— 4.93	29.21	28	4.43	45.69	— 91
B4-D								
	Men	38	68.35	52.80	31	24.50	45.38	3.71
	Women	28	24.36	48.29	28	7.43	40.00	1.43

Subjects of both sexes who report ease in making friends with hearing persons score as less neurotic and introverted and as more self-sufficient and dominant than subjects who indicate some difficulty in making friends with hearing people. For women, differences in score between the two groups are relatively slight, for men they are more pronounced. Men responding with "easy," score as decidedly more self-sufficient and dominant than men responding with "hard."

In general, these comparisons present a fairly consistent picture.

Individuals who communicate with the hearing chiefly by speech and who make friends readily with the hearing score as emotionally better adjusted and as more self-sufficient and dominant than deaf persons who resort to other methods of communication or who do not find it easy to make friends with the hearing.

In this connection it is interesting to note that of the deaf subjects who communicate with hearing persons principally by speech, 52 per cent of the men and 67 per cent of the women find it easy to make friends with hearing people. Among the deaf not depending in the main on speech in their relations with the hearing, 50 per cent of the men and 43 per cent of the women respond with "easy." That is, the proportion of deaf subjects who communicate with the hearing by various combinations of speech and writing and who find it easy to make friends with the hearing, is only slightly smaller than is this proportion among deaf cases depending for the most part on speech. This would indicate that success in making friends with the hearing involves probably factors additional to a particular mode of communication. It is possible that differences in personality adjustment play a part.

ANALYSIS OF RESPONSES OF THE DEAF TO SPECIFIC TEST QESTIONS

An analysis was made of the responses to those questions of the Bernreuter *Inventory* which had been split into two parts—the first part of the question applying to the subject's behavior in a given situation with hearing people, the second in relation with the deaf.

The percentage of deaf subjects responding with "yes," "no," and "?" respectively to questions bearing on behavior when among the hearing and when among the deaf is shown in Table 10. Responses reveal a persistent tendency for a larger number of both men and women to feel more uninhibited and at ease when with deaf companions than when with the hearing.

For instance, only three per cent of the men and 14 per cent of the women state that they are troubled with shyness among deaf people. On the other hand, 24 per cent of men and 47 per cent of women say that they are troubled with shyness among the hearing. Similarly, a smaller percentage of subjects are very talkative at social gatherings, take the responsibility for introducing people at a party,

TABLE 10

PER CENT OF DEAF SUBJECTS RESPONDING WITH "YES," "NO," AND "?" RESPECTIVELY TO QUESTIONS BEARING ON BEHAVIOR AMONG THE HEARING AND THE DEAF

Inventory question	Men Yes	Men No	Men ?	Women Yes	Women No	Women ?
24a. Are you troubled with shyness among hearing people?	24	68	8	47	51	2
24b Are you troubled with shyness among deaf people?	3	90	7	14	80	6
28a. Are you very talkative at social gatherings of hearing people?	9	83	8	14	80	6
28b Are you very talkative at social gatherings of deaf people?	41	51	8	47	51	2
54a Do you often feel lonesome when you are with hearing people?	48	42	10	65	29	6
54b. Do you often feel lonesome when you are with deaf people?	8	87	5	2	90	8
87a. Do you take the responsibility for introducing people at a party of hearing persons?	43	32	25	45	41	14
87b Do you take the responsibility for introducing people at a party of deaf persons?	70	17	13	71	19	10
94a. Do you ever take the lead to put life into a dull party among hearing persons?	28	58	14	25	67	8
94b. Do you ever take the lead to put life into a dull party among deaf persons?	68	25	7	61	31	8
118a. Do you keep in the background at social affairs among hearing persons?	44	36	20	58	35	7
118b Do you keep in the background at social affairs among deaf persons?	23	68	8	24	76	0

or take the lead to put life into a dull party if hearing rather than deaf persons are involved. Likewise, keeping in the background at social affairs is reported more often in reference to social affairs among hearing persons than among the deaf.

The most marked difference, however, is found between parts *A* and *B* of the question, "Do you often feel lonesome when you are with hearing (or deaf) people?" Forty-eight per cent of the men say "yes" to this question in reference to hearing people, but only eight per cent give a similar reply when referring to the deaf, among women this difference is even larger, the percentages being 62 and 2 respectively.

SUMMARY

A study was made of the personality adjustments of deaf adults by means of the Bernreuter *Personality Inventory.*

The *Inventory* was tried out on deaf college students and, in slightly simplified form, on deaf adults. In both cases there were indications that the *Inventory* furnished a valid measure of personality, particularly in the traits of self-sufficiency and dominance.

Results obtained from administering the Revised *Inventory* to 50 deaf college students and to 126 deaf adults were analyzed

When compared with the norms supplied by Bernreuter for hearing populations, the deaf score as emotionally more unstable, more introverted, and less dominant than the hearing Deaf college students and deaf adult men rate as less self-sufficient and the deaf adult women as more self-sufficient than corresponding hearing groups.

Although some slight differences are found between the test scores of deaf and hypacousic groups, both of these groups in comparison with the normal hearing, are more neurotic, more introverted, and less dominant.

Among deaf adults, less amounts of neurotic tendency and introversion, and more self-sufficiency and dominance are found to be associated with the occurrence of deafness in later childhood rather than at birth or in infancy, the use of speech for communication with the hearing rather than writing, and ease rather than difficulty in making friends with hearing people. The percentage of cases experiencing difficulty in making friends with the hearing is only slightly larger for the group communicating with the hearing by writing than by speech

Responses to those items of the *Inventory* which permitted the adult groups to discriminate between their reports of behavior in situations involving the hearing and the deaf respectively, indicate that more of the subjects reported feeling socially at ease when with deaf companions than when among the hearing

This general picture of the personality of the deaf, supplemented by the previous studies by Welles and Pintner with the hard of hearing, seems to be more or less consistent It gives us confidence in the inventory as a whole and would seem to suggest its usefulness in the psychological examination of deaf individuals. The picture shows us a group of individuals, suffering from a very severe sensory handicap, reaching almost the same levels of adjustment in daily life as are on the average attained by fully normal individuals The deaf are only slightly more emotionally unstable, only a little more introverted and not quite so dominant as the normal hearing The deaf are not separated from the hearing by a sharp difference in their personality make-up. The remarkable thing is, of course, that they are able to adjust so well, despite the severe physical handicap Their adjustment seems to be just about as good as that of the hard-of-hearing Can we say that a slight loss of hearing seems to be about as disturbing to the personality as a total loss?

Another interesting suggestion arising from our study seems to be that the later in life deafness occurs the more chance the individual seems to have of making normal personality adjustments We know from many other studies by Pintner and others that the later in life deafness occurs the more language will the deaf individual acquire. A better equipment in language leads to more use of speech in later life and this means more normal relations with hearing individuals The more speech a deaf person can make use of, the more he is likely to feel on a par with his hearing fellows. Our data do not show that the teaching of speech makes for better adjustment. To show whether it does or not would require a much more elaborate experiment All that our results show is that those who become deaf later in life and, therefore, acquire language and speech more readily are in general more like the hearing in their personality. From all this it would seem to be a reasonable inference that speech helps the deaf to approach nearer to the hearing in their personality adjustments But we must not make the error of supposing that it is only speech that does this, and therefore make speech the be-all and the end-all of the education of the deaf. A more detailed study than our present one is required to disentangle the many factors in this complicated situation.

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VISUAL DISCRIMINATION IN THE CAT V THE POSTOPERATIVE EFFECTS OF REMOVAL OF THE STRIATE CORTEX UPON INTENSITY DISCRIMINATION*[1]

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I. INTRODUCTION

In recent years numerous advances have been made in our knowledge of the rôle of the cerebral cortex in the mediation of visually controlled responses. Contrary to earlier mistaken beliefs it is now known that infra-human mammals are not made completely blind by the abolition of the cortical areas concerned in vision The studies of Lashley (31, 32, 33, 34, 35, 38, 42), extending from 1920 up to the present day, and of Marquis (44), in 1934, showed clearly *for the first time that certain optic capacities*, besides those involved in the pupillary and palpebral reflexes, still persist after extirpation of the striate areas. However, the nature of this residual function, the understanding of which is basic to more complete knowledge of the integration of visual processes within the brain, is as yet incompletely known. Accordingly, the attempt is made in the present study to secure additional data relating to the effects of removal of the striate cortex on the measured visual capacity of the cat in intensity discrimination.

II. PRIOR INVESTIGATIONS OF THE FUNCTIONS OF THE VISUAL CORTEX IN MAMMALS

The nature of the optic defects produced by removal of the visual cortex has long been of interest in scientific investigation Early studies of this sort were primarily motivated by the attempt to understand the nature of the anatomical relations existing between the retina and the projection areas of the cerebral hemispheres,

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[1] Preliminary reports of certain aspects of the present study have been *given previously by the writer (70, 74, 75)*

and, as is well known, the visual parts of the cortex were approximately delimited by such study before the precise localization of this region was established by anatomical investigation

Only secondarily were early workers in this field concerned with the problem of analysis of the nature of special visual functions mediated by the cerebral hemispheres Their methods of observation consisted mainly in noting whether or not animals deprived of the visual areas could still make commonly observed responses such as avoiding obstacles, locating food, or responding to movements of the experimenter. As a result of the early work of Munk (50) and later that of Minkowski (47) and Shafer and Brown (65), it was clearly established that these reactions can no longer be elicited when the occipital lobes are removed in the dog and in the monkey. Minkowski showed that these defects were maximal after extirpation of the striate areas and that similar permanent disturbances could not be brought about by extirpation of other cortical areas. Accordingly, these investigations laid the groundwork for the belief that removal of the visual areas in such animals as the dog and monkey brings about complete and permanent blindness

Not until the first published work of Lashley (31, 32, 33, 34) on intensity discrimination in the rat was the theory suggested that certain optic capacities are mediated by the subcortical centers of the optic system. Prior to the work of Lashley, observations of the effects of cortical destruction upon general visual reactions in rodents had been made by von Bechterew (4), von Gudden (21), Munk (50), and Ferrier (18), but the results of these studies were not conclusive in regard to either their anatomical or psychological aspects.

Lashley's experiments (31, 32, 33, 34, 35, 38, 42) upon intensity discrimination in the rat reopened the question of the functions of the cortex in vision, and in doing this they served to emphasize the need for a definite psychological approach to the understanding of the central mechanisms of visually controlled behavior That is, rather than dealing with vision in some general way as earlier workers had done, his studies were oriented toward the investigation of the neural control of measureable visual capacities. In consequence of such an emphasis, numerous comparable studies have been carried out in the attempt to determine the rôle of the cortex and of the subcortical neural centers in the determination of different specialized visual functions These studies are critically summarized below with reference to the separate headings indicated.

1 *Intensity Discrimination* Lashley's early studies on intensity discrimination in rodents were directed toward the question of the retention of learned discriminative responses to lights of different intensity after extirpation of various parts of the cortex In four experiments Lashley (31, 32, 33, 34) found that, with complete bilateral removal of the visual cortex, the animals lost an intensity discrimination habit which was established prior to the operations Nevertheless, these operated animals could relearn the habit when training was resumed The number of trials required to re-establish the habit was approximately equal to the number demanded in the preoperative training Lesions located outside the striate areas did not disturb the learned response With removal of only a part of the visual cortex, the response was temporarily abolished Under such circumstances, the number of trials required to relearn was found to be positively correlated with the extent of the cortex removed in the striate regions (Lashley, 38, 42).

In two later studies modifications were made in the conclusion concerning the relation between degree of retention of the intensity discrimination habit and extent of destruction in the striate cortex. A reanalysis of previous data (Lashley, 38) tended to show that the correlation applied only to the lateral aspect of the striate areas (the region necessary for pattern vision) so that if a part of this area was removed, or if this part was included in a more extensive extirpation of the striate cortex, the degree of retention was a function of the extent of the cortex destroyed More recent experiments with lesions confined entirely to the visual cortex have been reported by Lashley (42). The extent of the extirpations ranged from small restricted areas of destruction to complete removal of the striate cortex. In this study the correlation between the measured magnitude of the destruction and the retention of the intensity discrimination habit was practically as high as that found in earlier studies. However, when the animals were classified according to the extent of secondary degeneration of cells in the lateral geniculate body, no significant correlation between the magnitude of the degeneration and the retention of the habit seemed to be evident

Whereas the earlier experiments by Lashley (31, 32, 33, 34) were interpreted to show that the visual cortex functions in intensity discrimination according to its mass, the more recent study (Lashley, 42) is taken to indicate that this part of the brain works in an "all-or-none" way in the mediation of responses based upon differences in light intensity. The fact that many of the animals with partial lesions showed some loss in retention is explained by Lashley as follows:

> If cerebral lesions were the only factor in inducing differences in the postoperative retention scores, we should expect to get a tri-modal distribution of scores, cases with no loss, cases with slight loss due to amblyopia in the residual visual fields, and cases with total loss But with the scores influenced by many other chance factors this grouping is partly obscured, so that an appearance of continuous variation, somewhat in proportion to the extent of the lesion is produced (p 60)

The previous conclusion that the striate cortex exercises an influence over sub-cortical centers to a degree proportional to its area is said by Lashley to be definitely wrong in the light of the later studies.

Further proof of the fact that all discriminative functions in vision are not mediated entirely through the cortical pathways of the optic system has been established in the studies of Marquis with the dog Marquis (44) has made use of a modified Yerkes-Watson discrimination apparatus, the general features of which were in every way comparable to the methods employed by Lashley, and as Lashley had also done, Marquis tested his animals under conditions in which illuminated test spots were presented against a dark surround. Two dogs which were trained prior to complete removal of the occipital lobes, temporarily lost but later relearned the discrimination habit after the operations The postoperative relearning involved somewhat fewer trials than did the original preoperative learning. Two additional dogs, not trained before complete extirpation of the visual cortex, demanded a few more trials to learn the habit than did normal animals.

More recently, Kluver (27) has been able to demonstrate that the monkey also is capable of visual learning subsequent to complete removal of the occipital cortex Using techniques somewhat different from those employed in the studies of Lashley and of Marquis, he found that one monkey with complete removal of the striate areas could be trained to respond to differences in the level of illumination in the experimental room or to differences in the luminous intensity of two small boxes placed outside the animal's cage.

The studies of Lashley (31, 32, 33, 34) raised the question as to whether or not the capacity for intensity discrimination in animals lacking the visual cortex is comparable to that in the normal animal. An attempt was made to answer this query in additional experiments with rats (Lashley, 37) in which the threshold of intensity discrimination was determined after varying degrees of destruction in the striate areas Normal animals discriminated the brighter of two lights until the ratio between their intensities was reduced to approximately 1.5 The rats needed no added training as the intensity ratio was decreased Operated animals, however, required added training at each change in the ratio of the two lights and showed rather marked increases in threshold values Lashley concluded that the threshold loss in these animals was roughly proportional to the extent of the lesion

Marquis (44) determined threshold values for intensity discrimination in four dogs in relation to complete removal of the occipital lobes He failed to find marked threshold changes after the operations, and holds that the threshold of light discrimination is only slightly affected by removal of the occipital lobes. In addition, the postoperative thresholds in animals which were trained and tested prior to the operations were found to be about the same as those which were not trained and tested until after the operations had been carried out.

Other experiments on the effects of removal of the visual cortex upon differential reactions to light intensity have been reported Marquis (45, 46) found that reflex closure of the eyelids can be conditioned in dogs and monkeys following complete extirpation of the occipital lobes. The results of the experiments showed, in general, that such responses are not significantly modified by this operation Ten Cate (13), however, failed to secure conditioned responses (approach to the door of a cage for food) to a bright light in decorticate cats or in cats lacking the visual areas, but Culler and Mettler (16) and Poltyrew and Zeliony (58, 59) report simple conditioned reactions to changes in visual intensity in decorticate dogs

The exact nature of the subcortical neural mechanisms which mediate discriminative responses to differences in light intensity are incompletely known. Freeman and Papez (20) showed that permanent defects in intensity discrimination could not be brought about by injuries to the superior colliculi in rats, and Layman,[2] as reported by Lashley (42), found that an intensity discrimination habit could be reestablished in rats after combined injuries to the superior colliculi and the optic thalamus.

Lashley's recent experiments (42) have contributed additional data concerning the effect of lesions in the superior colliculus and in the optic thalamus upon intensity discrimination. Animals with complete removal of the area striata and with unilateral distribution of the optic tracts beyond the external geniculate body lost the ability to discriminate differences in light intensity but relearned the habit in about twice the number of trials required in the initial training Animals with removal of the striate cortex, in conjunction with partial destruction of the optic tracts on one side and complete interruption of these tracts on the other, relearned the habit but did not respond as consistently as did those with injury to the tracts on only one side Animals with removal of the striate cortex, in conjunction with complete bilateral interruption of the optic tracts above the external geniculate body, lost the habit and could not relearn it. According to Lashley (42), these results would seem to show that the superior colliculus and optic thalamus contain pathways which are of primary importance in the mediation of the intensity discriminations, although it is impossible to determine the relative importance of either of these centers alone since fibers passing to the colliculi cannot be destroyed without injury to the optic thalamus.

2 *Pattern Discrimination.* In additional experiments, Lashley (37) investigated the effect of cortical ablations upon pattern vision. All observations were made under conditions of high illumination. The results of the investigation showed, as did those of a later similar experiment by Lashley and Frank (43), that pattern vision is permanently abolished by elimination of the cortical pathways in the optic system.

The immediate conclusion from the experiments of Lashley (37) and Lashley and Frank (43) was that the visual cortex functions as a necessary component in the mechanism of pattern discrimination Lashley (42), however, has made certain reservations regarding such a theory since he was able to demonstrate some residual visual discrimination based upon the position of masses of light after removal of the visual cortex in the rat The fact that rodents possess the ability to respond to patterned differences in visual stimulation after interruption of the cortical connections of the optic pathways has also been brought out in the experiments of van Herk and Ten Cate (22) and Ten Cate (14) These investigators observed that two rabbits with removal of the visual cortex could still be trained to approach and obtain food when a food plate was presented before them. They also found that the animals recovered a certain degree of visual ability in responding to other types of patterned visual stimulation.

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[2] Since this was written, a report of this work has been published by Layman. (Layman, J D, Functions of the superior colliculi in vision *J Genet Psychol*, 1936, **49**, 33-47)

No comprehensive training studies on pattern discrimination after complete removal of the occipital lobes have been carried out with mammals higher than the rodents The early studies of Bechterew (5) and Minkowski (47) showed that the ability of dogs to respond visually to pieces of food held before their eyes is abolished, but their studies did not involve training methods. Similarly, Bard and Orias (2) observed that visual placing reactions of the forelimbs are permanently lost as a result of extirpation of the striate areas in the cat The present writer (73, 78) has observed these reactions of the cat under many different stimulating conditions, in which striated patterns of different size and illumination were employed. Evidence was obtained that these reactions were permanently lost under all conditions of stimulation after complete extirpation of the striate areas.

Other investigations which have been carried out on pattern discrimination in mammals other than rodents have been incomplete in many details Rizzolo (64) has reported a high degree of acuity for the discrimination of striated patterns in the dog after excision of the occipital lobes, but he presents no proof that the operations involved all of the optic cortex Kluver (27) carried out observations on pattern vision in one monkey after complete occipital lobectomy In testing this animal Kluver made use of a rather complex response in which the animal was required to locate the position of a lighted box that was associated with food. No differential responses were found after the operation had been carried out

The effect of extensive destruction of the occipital cortex upon pattern vision in primates has also been studied by Spence and Fulton (79). They failed to find evidence for the discrimination of horizontal and vertical lines after almost complete destruction of the striate areas in the chimpanzee. The animal used in their experiment was tested after each of two stages of an operation which involved all visual cortex except the area of the projection of the temporal crescent of the right retina upon the right hemisphere After the first operation it was observed that there was a 5 to 15 per cent decrease in the ability of the animal to respond to the lines, but with the second operation, in which the striate cortex of the right hemisphere was removed, the animal could no longer be made to discriminate the striated patterns

Along with his studies on intensity discrimination, Marquis (44, 45) was concerned also with the understanding of other effects produced by removal of the occipital lobes in the dog These defects, many of which were observed by early investigators in this field, consisted mainly in the failure to respond to threatening or friendly gestures, the inability to avoid obstacles without coming into direct contact with them, the failure to find food efficiently, etc. Since the dogs used by Marquis could discriminate light intensities almost as well as normal animals under certain conditions of illumination, he assumed that this capacity existed under all conditions of general illumination and that factors other than disturbances of intensity vision were responsible for bringing about the defects mentioned. These defects he characterized under a single term called "object" vision, which he states consists in the response to the spatial characteristics of the stimulus, its position, distance, pattern and size According to Marquis, removal of the visual cortex in the dog abolishes such object vision whereas the ability to discriminate differences in light intensity remains undisturbed

In postulating this critical division or independence between the neural mechanisms of light discrimination and object vision, Marquis (44, 45) also takes into consideration certain differences in the effects of removal of the striate areas in different animals The differences emphasized by him are those apparently existing between rodents and higher animals in regard to pattern and "object" vision. Evidence obtained from studies seemed to show that there is some degree of pattern and object vision in rabbits after removal of the visual cortex, while in higher mammals, according to Marquis, this capacity is abolished by similar operations Marquis also believes that there are significant differences between infra-human mammals and the human individual with respect to the effects of removal of the visual cortex upon light discrimination. This belief is based upon data taken from a number of clinical cases which gave evidence of total loss of vision, including light vision, after complete bilateral destruction of the calcarine cortex.

In the view of Marquis (44, 45), these differences in the effects of extirpation of the visual cortex in different mammals represent a phylogenetic change in the neural mehanisms of vision, in which the striate cortex becomes progressively more important in the mediation of object vision and light discrimination In rodents, for example, pattern or object vision is mediated in part by the superior colliculus and other subcortical mechanisms, as well as by the cortex, but in carnivora and higher mammals this function has been shifted entirely to the visual areas A similar "encephalization" or "corticalization" (Dusser de Barenne, 17) is said to take place with respect to intensity discrimination in the case of man. The main anatomical evidence cited by Marquis which he believes can be pointed to as a correlate of the encephalization of visual function within the mammalian series is that brought out in the studies of Brouwer and his collaborators (8, 9, 10, 11) Overbosch (as cited by Brouwer, 8) was able to show that an orderly projection of the retinal quadrants upon the superior colliculus can be found in rabbits, but no such discrete correspondence between the retina and the superior colliculus was observed by Brouwer and Zeeman (11) in the cat and monkey Brouwer (8) states, however, that some evidence for an orderly arrangement of visual fibers in the superior colliculus was brought out in the experiments with the monkey.

3 *Movement Discrimination*. There is available at the present time no clear-cut evidence concerning the relation between cortical function and movement discrimination, and it is not known whether or not the data presented above in connection with pattern vision apply also to the case of the discrimination of moving patterns. Pavlov (53) describes experiments of Koudrin in which a conditioned differentiation between moving and non-moving luminous patterns was established in a dog after removal of the occipital lobes, but Pavlov's description of these experiments makes it impossible to form any definite conclusions concerning the cortical mediation of move-

ment discrimination Similarly, results of Kennedy and the present writer on cats (26) do not permit any final judgment as to whether or not responses to moving stimuli can be established after extirpation of the striate areas. In these experiments, thresholds of real movement discrimination were determined in three cats before and after incomplete bilateral removal of the striate areas. In all three animals, a part of the visual cortex bordering the Sulcus splenialis was left intact. It was observed after the operations that the thresholds of all three animals were significantly increased, although discriminative responses could be secured consistently at the higher movement speeds. A more recent preliminary report of similar work by Kennedy (25) upon animals presumably possessing complete extirpation of the striate areas presents evidence for rudimentary types of pattern and movement discrimination in the cat after such operations.

Although present knowledge of the cortical mediation of learned responses based upon movement stimulation is incomplete, there is some evidence that removal of the visual cortex in mammals such as the cat does not abolish compensatory head and eye movements, which are made in response to moving striated patterns (Smith, 73, 76, 77) Observations of this sort, besides giving evidence for the mediation of responses to pattern differences by the subcortical neural mechanisms of vision, also seem to indicate a possibility of establishing learned responses to moving stimuli in the cat after removal of the occipital lobes The subcortical neural mechanisms of the ocular reactions in the cat definitely seem to be capable of mediating responses of the eyes and head to moving striated patterns.[8]

4. *Size Discrimination* The effects of removal of the visual cortex upon size discrimination have been studied by Lashley (39) and Kluver (27) Using rats, Lashley observed that two visual stimuli of equal intensity but of unequal size could be discriminated by animals after all striate cortex had been destroyed However, when the total luminosities of the two stimuli were equated, keep-

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[8] Similar views concerning the discrimination of stationary striated patterns have recently been advanced by Lashley on the basis of experiments with rats Unpublished data secured by the writer also indicate the presence of residual capacities in the discrimination of stationary lines in cats lacking the striate areas

ing the size differences constant, the animals could no longer be trained to make discriminative responses Similar results have been reported by Kluver in experiments with a monkey in which the striate areas were destroyed.

5 *Color Discrimination* Franz' investigations (19) of color sensitivity in the monkey constitute the only available experimental work bearing upon the cortical mediation of learned discriminative responses to wave-length differences in infra-human mammals Franz had one animal in which most of the calcarine cortex was destroyed Along with other observations he noted that the animal's ability to discriminate differently colored pieces of bread was lost and could not be reestablished Other animals with lesions confined to the dorsal surfaces of the occipital lobes could still react discriminatively on the basis of visual cues in the selection of the colored pieces of bread Experiments by Kluver (27) with one monkey, in which the occipital lobes were almost completely destroyed, have been taken to show that such an operation may influence the effectiveness of certain spectral colors according to their visibility

6 *Temporally Determined Discrimination* Up to the present time, the relation between cortical function and flicker discrimination has not been investigated, nor have studies been made of other differential responses based upon temporal variation in the stimulus. *Furthermore, the experimental work already carried out in connec*tion with other special visual functions seems to establish no adequate basis for inferences concerning the cortical mediation of temporally determined reaction in vision

7. *Extra-visual Functions of the Striate Cortex.* In addition to possessing the special visual functions described above, the striate areas are involved to some extent in the maintenance of activities whose afferent control is not of visual origin Tsang (82), for example, has shown that in rats, in which the eyes were removed at an early age, extirpation of the striate areas at a later age induced marked defects in the retention of a learned maze habit. Similarly, Krechevsky (29, 30) has shown that preferential responses in an insoluble problem situation may be changed by destruction of brain tissue involving the striate areas These studies may be considered as significant in evaluating generally the results secured on ablation of the occipital cortex, since they prove that part of the disturbance observed after this operation is not entirely attributable to a strictly visual deficit.

III Problems

The investigations cited above raise numerous unsolved questions concerning the functions of the mammalian visual cortex. It is believed that certain of these problems may be approached by the study of defects following removal of the striate cortex in the cat. At the present time, such a study has particular reference to the following main questions. (*a*) What relation exists between the extent of destruction in the striate cortex and the capacity to discriminate differences in light intensity? (*b*) Does removal of the striate areas affect intensity discrimination equally at different levels of general illumination (intensity surround of the differential stimuli)? (*c*) Does removal of the striate areas affect intensity discrimination equally at different intensity levels? (*d*) To what extent are defects in intensity discrimination involved in the general visual deficit produced by extirpation of the striate areas?

IV Methods and Results of the Present Investigation

1. *Behavior Methods* A lever discrimination apparatus, which has been described elsewhere by the writer (66, 69) was employed in the present experiments (Figure 1) This apparatus, found in previous studies to be well suited for the study of visual acuity (67, 77), pattern vision (68, 71, 72), flicker discrimination (23, 24), and movement vision in the cat (25, 26), is modified in the present

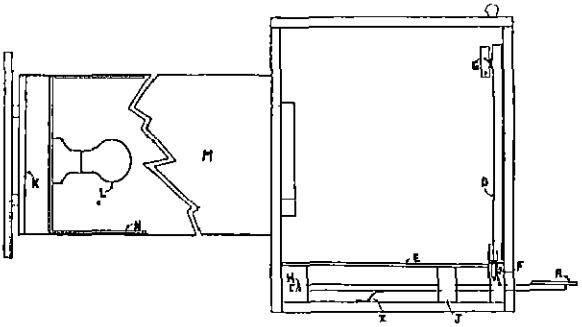

FIGURE 1

The Discrimination Apparatus

A, lever, D, door, E, shelf, F, latch, G, master latch, H, lever support; I, spring; K, ventilating screen, L, light; M, metal tube; N, movable support for light.

investigation in order to permit the presentation of visual stimuli varying only in intensity.

The apparatus consists of a small box, 29 cm. long, 28 cm wide, and 33 cm. high, painted flat black A door (*D*), a wooden frame 1.9 cm wide, swings inward by means of springs attached to its rear side Its front side is fitted with grooves into which frosted glass or cards bearing various types of visual stimuli may be easily inserted or removed. The latch of the door is controlled by a metal lever extending from inside the box, and terminating in a brass plate of a size ample to accommodate the paw of the animal The cat obtains food placed on the shelf (*E*) by depressing the lever and thrusting its head and forebody through the aperture of the opened door

A filter holder is mounted over an aperture, 10 cm by 12 cm., cut in the rear panel of the box. This holder is constructed to permit the insertion of two 4 x 5 photographic filters, which when inserted in their places do not allow stray light to pass inside the discrimination box. A diffusing screen is mounted on the other side of the aperture in order to aid in spreading the light inside the front part of the apparatus. The inside of the apparatus is painted white.

Extending backward from the box and centered over the small aperture is a metal tube (*M*), 20 cm. in diameter and 90 cm. long, which contains the light (*L*), a 200-watt lamp, that is supported at the center of the tube by the metal brace (*N*). A ventilating screen is arranged to fit the end of the tube, as shown in the diagram

In the experiment, two of such boxes are placed on runways, 5 cm wide, which extend outward from the end of a long runway table (Figure 2) The runways and the table are both 60 cm. high. The fronts of the two boxes are located 50 cm away from the end of the table, and their centers are separated by an equal distance.

A restraining cage of suitable size is placed at the other end of the runway table Its front side contains a sliding door which is controlled by the experimenter from a position at the rear of the experimental room.

The subject, upon release from the restraining cage, walks along the table and one of the runways and depresses the lever on one *of the discrimination boxes Electrical punishment for an incorrect*

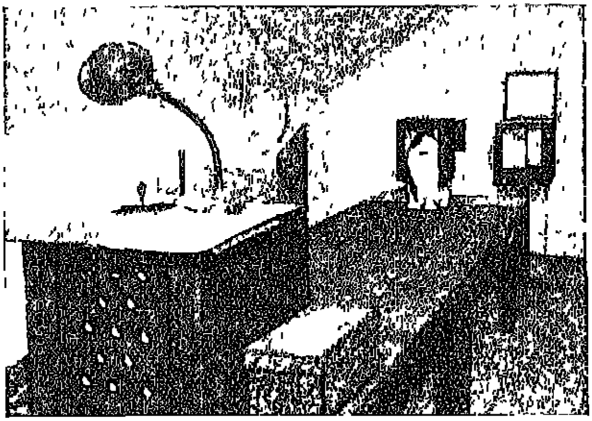

FIGURE 2
THE ARRANGEMENT OF THE DISCRIMINATION BOXES DURING THE EXPERIMENT

response may be administered through copper-wire grills placed on the runways and galvanized-iron flooring covering the end of the table. This arrangement of the electrodes of the electrical circuit giving the shock requires that the animal make the discrimination at the end of the runway table

The animal is first accustomed to the experimental situation by preliminary feeding in the apparatus Training in depressing the levers of the discrimination boxes is begun when the cat learns to leave the restraining cage and go directly to the opened boxes in order to secure food. After the habit of manipulating the levers is thoroughly established, training with visual stimuli is begun by presenting lights or cards of different intensity in the doors of the discrimination boxes Each animal is given a series of 20 trials per day

2 *Operative Procedure and Remarks Concerning the Central Visual System of the Cat* The extent and character of the visual cortex in the cat (Figure 3) was first described by Campbell (12), whose findings in the main have been confirmed by most subsequent investigators (Alouf, 1; Brodmann, 7, Koppen and Lowenstein, 28; Minkowski, 48; Winkler and Potter, 83). This region of the cortex covers the posterior part of the Gyrus lateralis and all of the Gyrus lateralis posterior on the dorsal surface of the brain.

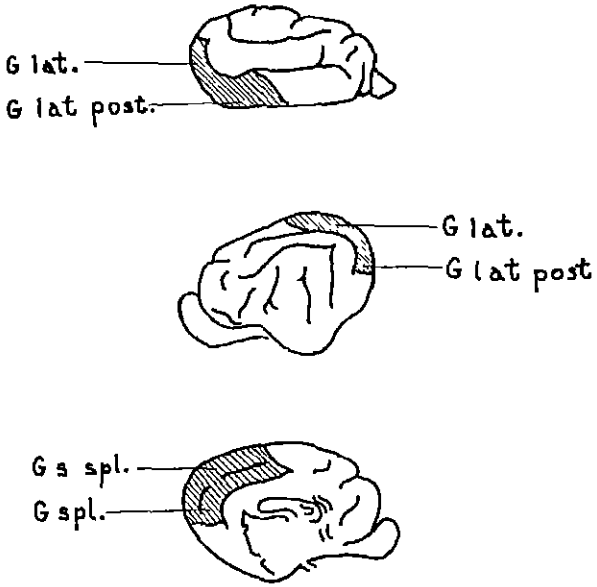

FIGURE 3
THE VISUAL CORTEX OF THE CAT
(Redrawn from Campbell)

Medially, the area includes the Gyrus supra-splenialis along its entire extent as well as a part of the Gyrus splenialis

The relations of the striate cortex to the external geniculate body in the cat has been investigated by Barris (3), Minkowski (48, 49), and Poliak (54). As shown by Minkowski, the ganglion cells *of the external geniculate body degenerate following complete extirpation* of the striate areas Minkowski also showed that the *binocuar portion of the external geniculate body (i e, that region* receiving fibers from the parts of the two retinae overlapping in binocular vision) is projected upon the posterior portion of the striate cortex in the cat's brain.

The external geniculate body in the cat has been described in detail by Thuma (81), while the relations of the nucleus to fiber tracts and other centers of the visual system have been investigated by Rioch (62, 63). According to the work of Overbosch, whose results are summarized by Brouwer (8), the retinal quadrants and the binocular regions of the retina are projected in an orderly fashion upon the external geniculate body In general the anatomical results concerning the projection of the retina upon the external geniculate body and upon the striate cortex in the cat seem to follow in almost all details similar data obtained with other mammals (Lashley, 40, 41; Putnam and Putnam, 61; Brouwer, 8, 9, 10, Brouwer and Zeeman, 11, Poliak, 55, 56, Poliak and Hayashi, 57)

The relations between the striate cortex and other projection centers of the optic system in the cat have been described in part by Barris (3), Minkowski (48, 49), and Poliak (54) Barris has shown that there is secondary degeneration of cells in the superior colliculus after lesions in the striate areas, and Minkowski states that removal of the striate cortex brings about a not insignificant extent of degeneration in the superior colliculus In the monkey, Poliak (55) failed to find evidence for direct corticofugal connections between the striate cortex and the superior colliculus The nature of the projection of the retina upon the superior colliculus in cats is not clearly understood. Brouwer and Zeeman (11) obtained no evidence for discrete areas of degeneration in the superior colliculus after lesions of the retina in cats. They did find, however, that lesions of the retina in monkeys produced localized areas of degeneration (Brouwer, 8) This fact seems to suggest that, in primates, the midbrain retains some of the importance as a primary projection center that it is known to have in lower vertebrates

Although lacking in completeness, current understanding of the central visual system in the cat is sufficiently advanced to serve as an adequate basis for further investigations of the functions of the brain in relation to the visual capacity of this animal. Further significance of the facts just cited to the present investigation will be pointed out below.

In the present experiments, partial and complete bilateral removal of the striate cortex was carried out on 12 animals under thoroughly aseptic conditions. All operations except that on one animal were performed in one stage by the aid of Nembutal (Pentobarbital sodium, 0.75 cc. per kilogram weight) anaesthesia. After adequate exposure of the occipital lobe through an opening under the temporal muscle, the striate cortex and surrounding tissue were partly excised by a thermocautery, and thereafter dissected out intact by means of a blunt spatula and dissecting forceps. The wound was tightly closed by suturing the temporal muscle, the superficial muscles, and the skin

Following the testing or retesting of the animals in intensity discrimination and other types of visually controlled behavior, the animals were immediately killed and the brain fixed in 10 per cent formalin by perfusion through the carotid arteries. After removal from the cranial cavity, the brain was washed in water and thereafter dehydrated in alcohols It was then embedded in celloidin and cut in complete frontal sections, 60 mm in thickness Every tenth section throughout the brain and every other section through the external geniculate body was stained with thionin and mounted individually on slides These prepared sections were later enlarged and drawings made of each section, which were used as a means for judging the relative extent of the lesion. In some of the animals with extensive destruction of the striate areas, a complete investigation of the extent of cell degeneration in the lateral geniculate body was carried out.

The nature of the operations as viewed from the dorsal and medial sides of the brain can be understood by reference to Figure 4, in which are shown drawings of the extent of the lesions as graphically reproduced by the method described above. It will be seen from these drawings that in eight of the different animals the striate cortex was incompletely removed. In these eight cases the cortical destruction varied from restricted lesions in the posterior portion of the lateral gyrus to almost complete removal of this area.

In four animals (Subjects 17, 28, 29, 30) the striate cortex was completely removed as far as could be ascertained from observations of the extent of the lesions in the prepared sections. More complete anatomical controls of the extent of the cortical destruction in these and the other animals with extensive lesions was carried out, however, by means of the determination of the extent of secondary cell degeneration in the lateral geniculate body In accordance with prior observations that the dorsal nucleus of the lateral geniculate body completely degenerates after extirpation of the striate region, a careful determination of the presence of ganglion cells in this nucleus was made in the animals with the more extensive lesions As far as could be ascertained, these observations showed that there

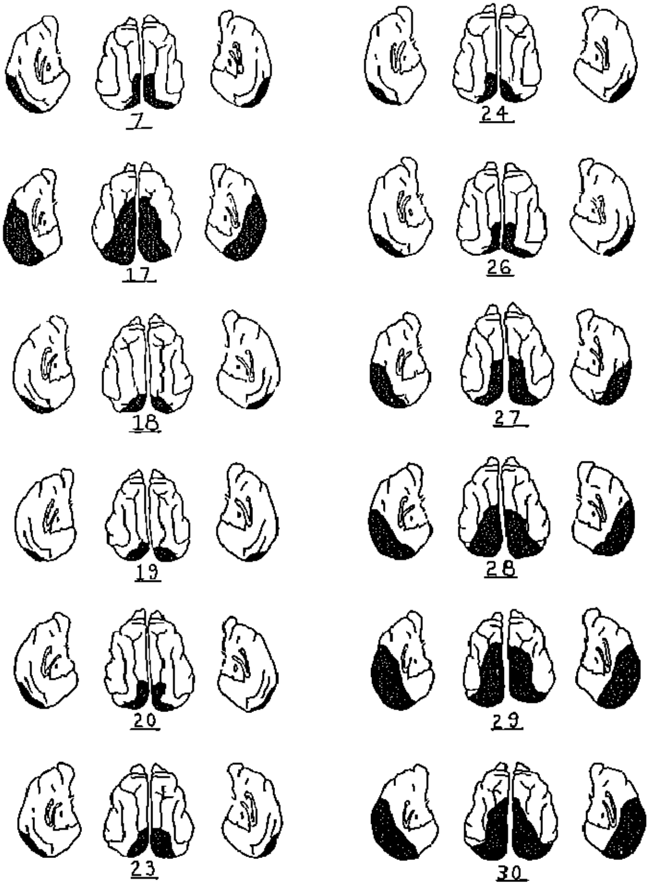

FIGURE 4

was a complete absence of ganglion cells in the dorsal nucleus of the external geniculate body in all four of the subjects As compared to the normal appearance of this nucleus, there was an increase in number of smaller and more darkly stained bodies. In four of the other animals with extensive but incomplete lesions, the degeneration of cells within the dorsal nucleus extended mainly over the medial and anterior portions of both of the geniculate bodies.

3 *Subsidiary Observations of Visually Controlled Behavior* The animals with the more extensive lesions were examined in detail concerning various aspects of visually controlled behavior besides that involved in the discrimination of light intensities All of the animals here designated as having complete destruction of the striate cortex gave clear evidence of defects in visual capacity which have been observed by prior investigators to be associated with removal of all striate cortex The animals failed to respond to any gestures or movements of the experimenter made within their field of vision. They would not fixate lighted objects or surfaces moved toward or past them. Under conditions of daylight illumination objects suddenly moved toward or past their heads failed to elicit reflex closure of the eyelids They were unable to locate food quickly or efficiently when it was placed in their near vicinity and such an incentive could not induce them to climb the sides of the cage or other elevated places Visual placing reactions of the forelimbs could not be elicited in any of the four subjects when they were moved toward differently illuminated and patterned surfaces, and with the abolition of these reactions, the ability to jump from elevated positions was also lost. In addition, their ability to orient visually to obstacles lying in the path of progression was abolished, except under the special conditions of training and discrimination which will be described in connection with the presentation of the results on intensity discrimination As far as could be ascertained these defects in visual control of typical responses were permanent in nature; i.e., they persisted as well marked as ever over the entire period of six to ten months during which the animals were under observation.

V RESULTS

1. *Visual Intensity Discrimination in the Normal Cat.* Before proceeding to the presentation of results bearing upon the effects of removal of the visual cortex upon intensity discrimination it is first necessary to describe in some detail the nature of this capacity in the normal animal.

In the present study thresholds of visual intensity discrimination were determined in eight animals. Six of these animals were later used in connection with studies of the effects of removal of the visual cortex One of the remaining animals died before it could be brought to the operation, while the other was retained as a laboratory subject for other purposes

Eight threshold determinations on seven different animals (Subjects 7, 17, 18, 19, 20, 21, 22) were made under conditions in which the lights from the stimulus boxes were the only illumination present in the experimental room These circumstances of stimulation will be designated hereafter as the dark conditions Five of these determinations were made with the standard light set at an intensity of 0 48 millilamberts while three were secured at an intensity level of 50 4 millilamberts After a stable discrimination between the lights in the stimulus boxes had been established, the liminal ratios were ascertained by a modified method of limits. The threshold was considered to have been reached when the animal failed to discriminate 75 per cent of the time in 20 trials during two consecutive 20-trial periods at a given intensity level

Table 1 presents the results secured on seven animals at the two different intensity levels employed The single column to the left represents daily trial periods of 20 trials each. The column marked (*R*) under the number of each subject indicates the different stimulus ratios employed as the difference between the two lights was reduced, while the columns marked (%) show the percentage of correct responses made during that trial period The threshold ratios of the different animals are given at the bottom of the table.

Reference to the table will show that there is some variation in the threshold ratios obtained with the different animals. The lowest values were secured with Subject 17 at both intensity levels and with Subject 20 at the higher intensity level. Subject 7 gave the highest ratio of 1 6. In general, the smallest intensity ratio discriminated by the animals at the low and at the high intensity levels varied approximately over the same range. Greater difficulty was encountered by the different subjects in transferring from one intensity ratio to a lower one as the threshold value was reached.

Tests were also carried out on one animal when the general illumination of the experimental room was raised by placing two parabolic reflectors containing 200-watt bulbs 100 cm above the runway table and 200 cm back away from the stimulus boxes. In this situation the animal discriminated between Hering grey papers, which were fixed on stiff cardboard and inserted into the

TABLE 1

THRESHOLD DETERMINATIONS ON SEVEN ANIMALS AT TWO DIFFERENT INTENSITY LEVELS

Intensity level	0.48 millilamberts						50.4 millilamberts									
Subject	7		17		18		17		19		20		21		22	
Trial period	R	%	R	%	R	%	R	%	R	%	R	%	R	%	R	%
1	102.0	100	102.0	95	102.0	90	32.6	100	103.0	100	103.0	100	103.0	95	103.0	95
2	71.0	95	69.0	100	69.0	75	6.2	100	50.0	90	50.0	90	50.0	100	50.0	95
3	69.0	95	59.0	90	51.5	90	6.2	95	24.5	95	24.5	95	11.8	90	32.6	85
4	59.0	95	51.5	100	36.8	90	4.2	100	11.8	95	11.8	75	6.2	95	8.2	90
5	51.5	95	36.8	85	33.0	85	3.2	100	6.2	75	11.8	85	4.2	80	6.2	85
6	36.8	100	23.6	90	16.8	90	2.8	95	6.2	80	11.8	95	3.2	85	4.2	80
7	23.6	100	16.8	100	12.3	85	2.8	90	4.2	75	6.2	95	2.8	75	3.2	70
8	16.8	95	12.3	90	8.7	90	2.0	85	4.2	85	6.2	100	2.8	70	3.2	85
9	12.3	100	8.7	80	4.2	55	2.0	100	3.2	70	4.2	95	2.0	75	2.8	90
10	8.7	95	4.2	95	4.2	55	1.6	90	4.2	90	3.2	100	2.0	80	2.0	70
11	4.2	90	3.2	95	3.2	80	1.38	65	3.2	90	2.8	90	2.0	85	2.0	80
12	3.2	95	2.5	75	3.2	90	1.38	90	2.8	80	2.0	95	1.6	55	2.0	80
13	2.5	90	4.2	75	4.2	80	1.27	70	2.0	55	1.6	70	1.6	60	1.6	90
14	4.2	90	3.2	95	3.2	90	1.24	75	2.0	70	2.0	80	1.38*	75	1.38	75
15	2.5	50	4.2	85	2.5	80	1.24*	85	2.8	80	1.6	60	1.38	55	1.24	60
16	4.2	90	3.2	95	2.5	80	1.24	65	2.8	75	1.6	85	1.24	70	1.24	70
17	3.2	90	2.5	90	1.23	75	1.27	70	1.6*	85	1.38	80	1.6	90	1.27	55
18	3.2	95	1.23	80	2.5	85	1.27	70	1.6	80	1.38	70	1.38	65	1.6	85
19	2.5	90	2.5	80	1.23	65	1.2	40	1.38	70	1.24*	75			1.38*	90
20	1.6*	85	1.23	85	1.1	55	1.27	65	1.38	60	1.24	65			1.2	60
21	2.5	90	1.1	70	2.5	95			1.24	65	1.27	85				
22	1.23	60	1.23	90	1.29*	80			1.24	60	1.2	60				
23	1.6	80	2.5	90	1.35	85					1.27	80				
24	1.23	65	1.29	75	1.35	75					1.2	45				
25	1.1	60	1.35	90	1.23	70										
26	1.1	55	1.35	80	1.1	60										
27	1.1	60	1.29	85	1.29	55										
28			1.23*	75												
29			1.1	55												
30			1.1	45												
Threshold value	1.6		1.23		1.29		1.24		1.6		1.24		1.38		1.38	

door of the discrimination boxes. A paper giving an intensity level of 47 1 millilamberts was employed as standard.

The single animal employed in this part of the investigation required 60 trials to reach 100 per cent correct choice of the standard paper during the training series. Thereafter, the difference between the standard brightness and the variable brightness could be reduced to a ratio 1 4 before the limit of the animal's capacity to discriminate between the two brightnesses was reached. This value lies within the range of threshold ratios secured under the conditions described above in which the surrounding illumination was as a minimum.

It is believed that the responses found can be proved to be a function of the brightness ratios employed in the experiment. The fact that the discriminative behavior of the animals can be demonstrated to be limited consistently by a threshold value of light intensity validates the experimental results in a positive way. In addition, the responses of none of the subjects were found to depend upon the electric shock used as punishment, since brightness ratios above the threshold values elicited discriminative behavior when the current giving the shock was discontinued. That other secondary sources of stimulation were not involved in the behavior is shown by the fact that at no time could a discriminative response be elicited when the regular procedure of the experiment was followed and stimuli of equal brightness employed.

2. *The Effects of Removal of the Striate Cortex upon Intensity Discrimination.* The results of this part of the experiment may be summarized under the following headings: (*a*) the effects of removal of different amounts of the striate cortex upon the retention of the brightness discrimination habit when the intensity of the surrounding illumination is at a minimum, (*b*) the effect of such operations upon thresholds of brightness discrimination under conditions similar to those used in (*a*), (*c*) the effect of removal of the striate cortex upon learning and retention of the brightness discrimination habit under different conditions of general illumination.

(*a*) *Retention of the Brightness Discrimination Habit under Conditions of Minimum General Illumination.* Twelve animals were employed in this part of the experiment. In addition to the preoperative training in the discrimination habit, thresholds were determined in four of the animals (Subjects 7, 17, 18, and 20) prior to the operations. Two animals (Subjects 23 and 29) were un-

TABLE 2

Operation	Incomplete																	Complete						
Subject	7		18		19		20		23	24		26		27		30		17		28		29	30	
Training	Pre	Post	Pre.	Post	Pre	Post	Pre.	Post	Post	Pre	Post	Pre.	Post	Pre	Post	Pre.	Post	Pre.	Post	Pre	Post	Post	Pre	Post
Trials																								
0- 20	55	100	75	90	40	85	30	100	75	50	90	60	95	70	85	65	85	55	65	60	70	65	65	55
20- 40	65	100	75	100	40	95	40	100	80	80	100	45	100	65	90	55	90	50	60	70	55	75	55	70
40- 60	65		55		35	100	55		75	85		55		80	100	55		60	75	55	65	80	55	70
60- 80	55		70		60		45		85	80		50		90		65		80	70	55	75	70	65	75
80-100	90		65		90		60		80	70		55		85		60		95	80	60	60	80	60	70
100-120	75		90		95		75		90	90		70		90		80		100	75	75	60	85	80	65
120-140	100		75				85			65		75		100		85			80	90	70	100	85	80
140-160			90				100			85		90				90			95	95	65	95	90	70
160-180										100		80				100			90		75		100	85
180-200										100		95									90			75
200-220																					85			90
220-240																					90			85
Criterion fulfilled	100	20	120	20	100	40	160	20	120	120	20	160	20	80	40	160	40	100	160	140	200	140	160	220

trained when the operations were carried out. Additional preoperative training given to Subjects 17, 28, and 30 will be mentioned in a later connection below.

Table 2 summarizes the results obtained on the 12 animals in the postoperative training carried out two weeks after the operations. These results are compared to those secured in the initial preoperative training The numbers in the tables indicate the number of trials required to reach 90 per cent correct choice of the brighter light in a 20-trial period Examination of the table will show that all animals with lesions designated as partial, and which were trained prior to the operation, immediately relearned the discrimination of the two lights Subject 30 also was able to discriminate between the stimuli immediately after a complete unilateral destruction of the striate cortex.

Animals with complete bilateral destruction of the striate area were at first unable to discriminate between the stimuli during the postoperative training. With subsequent training, however, all learned this response in at least 240 trials, and some in as few as 140 trials

The two animals which were not trained prior to the operation (Subjects 23 and 29), in one of which the striate areas were incompletely removed, required about the same number of trials to learn the discrimination in postoperative training.

The destruction of the striate cortex in these different animals ranged from small localized lesions in the posterior portion of the Gyrus lateralis, through lesions of intermediate size involving most of the visual areas, to complete removal of these areas. As shown in the table, there are no differences in the degree of retention of the habit which can be said to vary directly with the magnitude of the lesion The only marked variation found is that induced by complete removal of the striate areas, in which case the animals had to be retained for a period of time comparable to that required to establish the habit in the preoperative learning

(*b*). *Effect of Removal of the Visual Cortex upon the Threshold of Brightness Discrimination under Conditions of Minimum General Illumination* Thresholds of visual intensity discrimination were determined in six animals subsequent to the operations In three of these animals, determinations were made after the operations at both the high and at the lower brightness levels, although preoperative threshold measurements on two of these animals were secured only at the lower brightness level. Both preoperative and *postoperative determinations were carried out with Subject 20 at* the higher brightness level, while the threshold of Subject 23 was determined at the higher brightness level only after the operation.

Table 3 summarizes the results obtained in the different subjects

TABLE 3

THE PREOPERATIVE AND POSTOPERATIVE THRESHOLD RATIOS IN INTENSITY DISCRIMINATION AT TWO DIFFERENT BRIGHTNESS LEVELS

Brightness levels	0.48 millilamberts			50.4 millilamberts				
Subject	7	17	18	7	17	18	20	23
Preoperative	1.64	1.23	1.29		1.24		1.24	
Postoperative	2.5	2.5	1.64	1.32	2.2	1.38	1.38	2.8

at both the high and at the low intensity levels. Reference to the table will show that the threshold values showed no marked increase at either level. The only animals giving evidence of any significant threshold loss were Subject 17, the single animal of this group in which the striate cortex was apparently completely destroyed, and Subject 23, which was untrained prior to the operation. The threshold loss of Subject 17 was about the same at the two different brightness levels. Subjects 7 and 18, in both of which the striate cortex was incompletely removed, also showed no significant variation in threshold loss at the two different brightness levels.

The cortical destruction in the different animals employed in this part of the experiment involved small lesions restricted to the posterior part of the striate cortex (Subjects 18 and 23), lesions of intermediate size (Subjects 7 and 23) and complete removal of the striate areas (Subject 17). The degree of variation in the threshold of brightness discrimination among the animals employed in this study seems not to be significantly related to the extent of the extirpation of striate cortex. The degree of change in the capacity of the different subjects to discriminate differences in brightness is not remarkably greater than the variation found among normal animals.

(c). *Effects of Removal of the Striate Cortex upon Retention of the Brightness Discrimination Habit under Different Conditions of General Illumination.* Prior to the operations, three animals

(Subjects 17, 29, and 30) were trained in the discrimination of brightness under three different conditions of general illumination. These were conditions of (*a*) minimum general illumination in which the light from the stimulus boxes was the only light present in the experimental room, (*b*) low general illumination, in which two 15-watt bulbs were placed in the reflectors above the runway table; and (c) high general illumination, in which two 200-watt bulbs were placed in the reflectors above the runway table.

The striate cortex of the three animals employed in this part of the experiment was completely removed so far as could be ascertained from histological examinations of their brains and from subsidiary observations of their behavior. In the case of Subject 30, in which the operation was done in two stages, retests were run two weeks after the first operation as well as two weeks after the completed removal of both striate cortices Preoperative retention tests were carried out with two of the animals two weeks after the initial training

In Table 4 are summarized the number of trials presented to the three animals during the preoperative training, the preoperative retention tests, and the postoperative training in the three different situations employed. Numbers designating each subject are given at the top of the table, while the nature of the conditions of training and testing are described in the column to the right. Numbers in the table marked with an asterisk represent the fact that no learning took place during the number of trials indicated

TABLE 4

THE NUMBER OF TRIALS REQUIRED TO REACH NINETY PER CENT CHOICE OF THE BRIGHTER OF TWO LIGHTS DURING THE PREOPERATIVE TRAINING, PREOPERATIVE RETENTION, AND POSTOPERATIVE TRAINING SERIES UNDER DIFFERENT CONDITIONS OF GENERAL ILLUMINATION

Subject	17			28		30			
Operation	Complete			Complete		Unilateral			Complete
Stimulating conditions	Pre. Tr.	Pre. Ret.	Post. Tr	Pre Tr	Post Tr	Pre Tr.	Pre. Ret	Post Tr	Post. Tr
Dark conditions	100	20	160	140	200	160	20	40	220
Low illumination	60	20	100	40	200*	80	20	40	200*
High illumination	20	20	500*	60	500*	100	40	60	500*

*Failed to learn in the number of trials indicated

Examination of the results presented in the table will show that the three subjects required respectively 100, 140, and 160 trials in order to learn the primary discrimination in the first stimulus situation Thereafter, *when immediately presented with the situation* giving low general illumination, 40 to 80 trials were required to reestablish the habit Subject 17 discriminated at once when put into the third situation, but the remaining two animals had to be retrained for periods of 60 and 100 trials respectively During the preoperative retention tests all animals were able to maintain a level of correct choice in excess of 80 per cent in 20 trials

After complete removal of the striate areas all three animals demanded a period of retraining in the first situation exceeding their trial record during the initial preoperative training in this situation When presented thereafter with the second situation, two of the animals failed to exceed a chance percentage of correct responses within 200 trials. Subject 17, however, learned to discriminate in this situation within 100 trials. In the third situation, all three animals were run for a period of 500 trials without showing any evidence of being able to discriminate between the two stimuli.

After the first stage of the operation, Subject 30 was run in a series of control tests under exactly the same conditions as those described above. As seen in the table, the unilateral operation had almost no effect upon the ability of the animal to respond in all three situations This animal discriminated immediately when put into the first situation after the operation, thereafter transferred to the second situation, and when presented with the third situation required only 60 trials to relearn the discrimination. However, after the second stage of the operation, this animal failed altogether in learning the discrimination in the circumstances involving increased general illumination

V SUMMARY AND DISCUSSION

The results of the experiments just described permit certain tentative statements concerning problems raised earlier in this paper.

Thresholds of visual intensity discrimination in four adult cats were found to vary between ratios of 1 23 and 1 6 at a brightness level of 0 48 millilamberts under conditions in which the illumination of the surround in the experimental room was at a minimum. At a brightness level of 50 4 millilamberts under similar conditions *of intensity surround, comparable threshold ratios in five animals* varied between 1.24 and 1.6. Under circumstances of increased general illumination the threshold ratio of one animal was ascertained to be approximately 1.4 In this part of the experiment the brightness of the standard stimulus was kept at a value of 47 1 millilamberts.

These combined results seem to indicate that the visual capacity of the cat in intensity discrimination is equal to or may excel that of many other different infra-human mammals Although fairly crude methods were used here in making variations in light intensity the results seem consistent enough to permit certain conclusions concerning the sensitivity of the optic system in the cat The following general comparisons give some idea of the nature of brightness discrimination in this animal in relation to that of other mammals. Threshold ratios have been determined in different infra-human mammals to be as follows: albino rat—1 26-2.37 (Munn and Slater, 52); pigmented rat—2 0 (Lashley, 36); raccoon—1 26 (Munn, 51); dog—1 2 (Marquis, 44; Stone, 80) As far as is known these values, although not exactly comparable, are based upon measurements made by essentially similar methods over the median range of illumination. In general it may be said that as far as the present study has gone, the capacity of the cat in intensity discrimination is of an order found in other sub-primate mammals, but inferior to that of the monkey. However, it should be pointed out that under the conditions used in the present experiments the threshold ratios of the cat in certain instances approximated those of human subjects making observations under the same conditions. In addition, there seems to be no evidence that any marked variation exists between the ability of the normal animal to discriminate differences in light intensity at low and at high conditions of general illumination.

Two weeks after the removal of varying amounts of the striate cortex, 12 animals were trained and tested in the discrimination of brightness differences under conditions in which the illumination of the surroundings was at a minimum. The extent of cortical destruction in these different animals included small lesions in the posterior aspect of the lateral gyrus, lesions of intermediate size, lesions involving almost all of the striate areas, and complete removal of both striate cortices Animals with partial lesions showed no significant loss in retention of the brightness discrimination habit when tested two weeks after the operations Four animals with complete removal of the visual areas, however, lost the habit and had to be retrained for a period somewhat exceeding the number of trials required to establish the habit in the preoperative training The postoperative effects of removal of the striate cortex under these conditions seemed to be confined entirely to animals with the complete lesions

The observations made here on retention of the brightness discrimination habit after partial and complete removal of the visual cortex contribute further knowledge to a problem which has already been dealt with by Lashley (31, 32, 33, 34, 35, 38, 42) in experiments with rats. In a number of different studies Lashley found a positive correlation from .50 to 60 between the magnitude of destruction of striate cortex and the degree of amnesia in brightness discrimination. The more recent of these studies showed, however, that a correlation of this degree was not evident if the extent of the destruction in the striate areas was judged on the basis of secondary degeneration in the external geniculate body Therefore, from this evidence, Lashley concluded that the other correlations obtained by him are artifactual in nature, and that the effect of striate area lesions upon the retention of the brightness discrimination habit is all or none in character. The results of present experiments are in accordance with this more recent conclusion of Lashley, since lesions varying greatly in size were found to produce no concomitant variation in the retention of the intensity discrimination in the cat as long as some of the striate cortex was left intact. Loss in retention of the habit was found only with extirpations presumably involving all of the visual cortex.

Evidence presented here seems to show that partial and complete removal of the striate cortex has no marked effect upon the differential threshold of brightness discrimination as measured under circumstances in which the surrounding illumination is kept at a minimum. When theresholds were determined at the same intensity level, animals with lesions confined to a small part of the striate areas gave evidence of threshold losses approximating those of cats with all striate cortex removed. The threshold modification found in animals with both partial and complete removal of the striate cortex was not much larger than the variation in threshold ratios found among normal animals. Evidence was also secured that partial and complete removal of the striate cortex does not produce different threshold losses at different intensity levels The threshold variations in the operated animals was approximately the same at two intensity levels which differed by a factor of 100.

The variation in threshold capacity produced in cats by partial and by complete removal of the striate cortex is of an order comparable to that found by Marquis (44) in the dog However, the present results do not show any significant relation between the magnitude of the destruction of the striate areas and loss in threshold capacity which has been brought out in an experiment by Lashley on the rat (35). The rather large variation in extent of striate area destruction in the cats studied in the present experiment and the small changes in thresholds found in the postoperative determinations seems to preclude the possibility of a significant relation between threshold loss and extent of cortical extirpation

The explanation for the fact that mammals suffer a temporary amnesia in intensity discrimination after complete removal of the striate cortex still remains an unsolved problem. The most plausible explanation of this effect now seems to be that the period of retraining required to reestablish the habit corresponds to a period of reorganization of subcortical visual mechanisms in relation to the sensory-motor mechanisms of locomotion and placing of the limbs The visually controlled limb and trunk reflexes, which are only partly cortically determined, must be recoordinated in relation to afferent impulses mediated by the subcortical visual pathways when the cortical component of their control is completely abolished These statements mean essentially that the relearning required after the operations involves not so much an increase in visual sensitivity as it does the establishment of new visual-kinaesthetic motor integrations These ideas suggest why there is a temporary loss of the discrimination habit but no marked reduction in threshold capacity after the operations.

Results were presented which showed that when animals lacking the striate areas are tested postoperatively under conditions of general high illumination, there occur apparent permanent disturbances in brightness discrimination which are not evident at lower levels of surrounding illumination. Three cats with complete removal of the visual cortex, although able to relearn the intensity discrimination when the illumination of the surroundings was at a *minimum, failed to relearn the same habit under conditions of* increased retinal illumination Two of the animals showed no evidence of relearning the habit within 200 trials at an intermediate stage of *general illumination In contrast, it was found that unilateral* removal of the striate areas had no effect upon the relearning of the habit under these different circumstances

These results seem to have direct significance to more general problems of the functions of the cortex in vision As a result of the experiments of Lashley with the rat (31-43), the opinion is *now held that removal of the striate areas abolishes the ability to* respond to visual patterns but leaves intact discriminations based upon differences in light intensity The fact should be noted, however, that the experiments of Lashley upon brightness discrimination were made only in circumstances in which the surrounding illumination was reduced as far as possible, whereas the studies on pattern vision were carried out under high illumination The results of the present experiments suggest that the level of general illumination at which defects of pattern vision were demonstrated in Lashley's experiments, disturbances in intensity discrimination may also be shown to exist.

Somewhat similar statements can be made in regard to the idea of Marquis (44) that there is a distinct separation of "object" vision and intensity discrimination within the central optic system. Marquis observed that complete removal of the striate cortex in the dog abolished the ability of the animal to respond to threatening gestures, to avoid obstacles, etc. But he also found that the same animals were very capable in the relearning of the discrimination between two lights which were presented in an otherwise dark room Extended tests showed that there was only a slight modification of the threshold capacity of the animals as a result of the operations

In giving an account of his experiments, Marquis (44) states· "The slight impairment of the threshold of light discrimination is not sufficient in itself to explain the entire visual defect The dogs bumped against objects held or moved before their eyes, even when the brightness difference between the objct and its background was many times greater than their threshold of discrimination" Marquis accounts for the ambiguity that under certain conditions his animals were apparently "blind" but could yet make almost normal brightness discriminations under other conditions by assuming that there is a distinct psychological difference between "light" vision and what he calls "object" vision. The ability to localize and respond visually to certain constellations of stimuli such as food, movements of the experimenter, and obstacles placed before the animal is taken by him to be indicative of "object" vision. On the other hand, a similar capacity to localize and respond to the correct stimulus in a brightness discrimination apparatus constitutes a different psychological function, i e., light vision According to Marquis, destruction of the striate cortex abolishes "object" vision but leaves intact this more primitive capacity of "light" vision.

It seems possible on the basis of the present results to give a solution of the problem raised in Marquis' experiments (44) without the making of unwarranted assumptions concerning the psychological nature of responses to various kinds of visual stimulation. The conditions used in the experiments of Marquis in which a deficit in object vision (so-called) was demonstrated, were conditions of general high illumination Evidently, as the present experiments clearly show, there is a distinct difference between the capacity of the operated animal to respond visually under such conditions and in circumstances in which objects of high intensity are presented against a dark surround According to the results obtained in the present investigation, the visual deficit resulting from removal of the striate areas can be described in terms of a defect in intensity or light vision, in so far as this capacity is measurable under conditions of high illumination of the surroundings. Or, more specifically, it should be said that this deficit involves in part disturbances in intensity vision under circumstances of increased general illumination

It seems clear, therefore, that no distinct division of neural function is involved in the mediation of brightness discrimination and what has been discussed by Marquis (44) as object vision Defects in brightness vision occur under the same conditions of stimulation in which disturbances in localizing responses to food, obstacles, etc , have been demonstrated Conversely, there seems to be no evidence that this capacity in orienting to objects is completely lost in circumstances in which intensity discrimination can be proven to be almost normal. Indeed, it may be argued that the ability of operated animals to localize and respond to the correct stimulus in a brightness discrimination apparatus is as indicative of object vision as is any other type of orientation to differences in visual stimulation

In the light of the present experiments, the impairment of vision in the cat following complete removal of the visual cortex seems *to involve disturbances which cut across different visual capacities*, including both intensity and pattern vision, depending upon the general conditions of a stimulation in which the animals are tested. The circumstances of stimulation in which little or no deficit is found in either intensity or pattern vision are those presenting marked gradients in retinal illumination, while circumstances associated with significant loss in both types of visual capacity are distinguished by reduced gradients in illumination. Proof of this fact has already been offered in connection with the discrimination of intensity differences in the cat, and the question may be raised as to whether or not the same description applies as well to other visually controlled responses.

In a former study, the writer (73, 78) has shown that this account seems to describe the effects of removal of the striate cortex in the cat upon the reactions of the eyelids to moving objects or "threatening gestures." The results of this study showed that cats deprived of the visual areas lose such responses when the *animals are tested under median levels of illumination.* Nevertheless, if the operated cat is held before an intense light source (500 watts) and the hand or a card moved across the visual field, the reactions still persist The increased gradient or contrast effect provided by the intense source seems to be necessary, therefore, in order to elicit such reactions in the operated animals.

Furthermore, such a description as that given above is apparently an adequate account of the modification in pattern vision after extirpation of the striate areas. The present writer (73, 78) has described experiments showing that, although fixation movements of the eyes and head (oculocephalogyric responses) to objects such as pieces of food, the experimenter's hand, etc., are abolished in the cat after removal of the striate areas, similar reactions to a rotating black and white striated pattern covering the entire visual field still persist after the operations In a further experiment (Smith, 76), it has been proved that the visual acuity of the operated animals under the latter conditions is approximately 11 minutes of arc or better, an acuity of pattern vision higher than that demonstrable in the pigmented or albino rat (Lashley, 36) The explanation of the abolition of pattern vision when the animals are tested with pieces of food or by moving the hand across the visual field lies in the fact that these situations do not present sufficient changes in retinal illumination or contrast in order to bring about forced reactions On the other hand, by increasing the gradient or change in retinal illumination by rotation of uniform black and white patterns across the visual field one may still secure definite responses to changes in visual pattern, and to a degree in the near vicinity of that of the acuity of the normal animal. In the former case sufficient change in illumination is not present for differential reactions to be produced in the more primitive subcortical neural pathways, whereas the uniform change in retinal illumination provided by rotation of the visual field will produce such reactions.[4]

Certain observations by Lashley (42), van Herk and Ten Cate (22) and Ten Cate (14) also point to the fact that certain types of pattern discrimination persist after removal of the visual areas in the rat and rabbit. Although Lashley (37) and Lashley and Frank (43) could not secure any indication of pattern vision in rats after complete extirpation of the visual areas, when the animals were tested under conditions of daylight illumination in which a diversity of patterned differences were involved besides those relating to the significant stimuli to be discriminated, Lashley did observe that such animals could still localize the position of patterns of light in an otherwise dark field. In addition, Kennedy (25) has presented tentative conclusions that the discrimination of moving patterns in the cat are not completely abolished by removal of the striate cortex

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[4] Since this series of experiments were reported, there has come to the attention of the writer a similar study by ter Braak (6) concerning the effects of removal of the striate cortex and of decortication upon visually controlled eye movements in the rabbit, dog and monkey Ter Braak distinguishes between what he calls fixation ("stier") and visual ("shau") nystagmus, and holds that the two can be considered as distinct because the latter involves "attention." He emphasizes that the former is present only with marked contrast in the visual field Observations on operated animals showed that decortication or removal of the occipital cortex in the dog and monkey abolished the "visual" nystagmus but left the "fixation" nystagmus intact These results seem to agree in detail with those reported by the writer, and the division of function left unexplained by ter Braak is apparently well accounted for in terms such as those just mentioned

Kennedy's animals were also tested under circumstances in which the significant stimuli were the only lights present in the experimental room. The experiments of Lashley (42) and of Kennedy (25) suggest that removal of the striate cortex does not completely abolish pattern discrimination, but leaves intact the ability to respond to visual patterns in situations presenting marked gradients or contrast effects between the figure and the background.

All of these results seem consistent in showing that extirpation of the striate areas, by reducing the efficiency of the entire optic system, brings about a limited disturbance in different visual functions rather than the complete abolition of certain specific functions such as pattern vision They appear, furthermore, to be generally contradictory to the view that in higher mammals there are independent levels of organization within the optic pathways, such that the higher levels may mediate pattern vision and the lower intensity or light vision A more plausible idea seems to be that this organization consists of a separation of neural control according to the degree of change in retinal illumination involved in either pattern vision or intensity discrimination. The circumstances in which both intensity and pattern vision seem to be demonstrable in animals without the striate cortex are those in which there are marked gradients in retinal illumination, such as are obtainable by presenting differential stimuli against a dark surround or by rotating patterns of light uniformly across the visual field Although the nature of this residual visual capacity seems to be similar in every respect to that found in animals possessing only rods in the retina, the relation between the visual capacity of animals without the striate cortex and the mechanism of rod and cone vision must be further investigated.

The following concluding remarks may be made concerning the results of the present study

1 An apparatus and technique is described which permits the controlled investigation of intensity discrimination in the cat.

2. Thresholds of visual intensity discrimination in the cat were found to vary between ratios of 1.23 and 1 6 at different brightness levels and with different levels of general illumination (intensity surround). The capacity of the cat in intensity discrimination seems to be of an order comparable to that which has been found in other sub-primate mammals.

3. The effects of partial and complete bilateral removal of the striate cortex was investigated in 12 animals in relation to the question of the retention of the intensity discrimination habit. Animals possessing partial destruction of the striate areas gave evidence of no loss in retention of the habit after the operations, while those having complete lesions required a period of retraining in the response comparable to that necessary to establish the original preoperative discrimination No evidence was secured that a direct relation exists between the extent of destruction of the striate cortex and the retention of the intensity discrimination habit.

4. Partial and complete bilateral removal of the striate cortex in five cats failed to produce significant variations in the thresholds of intensity discrimination which were determined at two different brightness levels Contrary to an earlier investigation of Lashley, no evidence was secured that there is a significant relation between the threshold of intensity discrimination and extent of destruction in the striate cortex.

5 The postoperative defects in the retention of the intensity discrimination habit as a result of complete bilateral removal of the striate cortex seem to be best explained in terms of the elimination of the cortical control of the limb and trunk reactions involved in the learned visual orientation and the reestablishment of the neural control of these reactions through subcortical neural centers.

6 Results are presented to show that, when animals lacking the striate areas are tested postoperatively under conditions of general high illumination (intensity surround of the differential stimuli), there occur apparent permanent disturbances in intensity discrimination which are not evident when such tests are made with stimuli presented against a dark surround. Three animals with complete bilateral removal of the striate areas failed to relearn an intensity discrimination habit under conditions of high general illumination although they were able to relearn this same habit easily when the surrounding illumination was at a minimum

7. The general visual deficit following complete removal of the striate cortex in mammals involves a disturbance in the ability to discriminate intensity differences under conditions of increased general illumination.

8. Arguments are presented to show that the general deficit in mammals following complete removal of the striate cortex does

not consist in the loss of certain specific functions (pattern and object vision) and the normal retention of other visual capacities (intensity and light vision) A more plausible view, in the light of the present results, seems to be that destruction of the striate area brings about a limited disturbance in both intensity discrimination and pattern vision

9 Since both intensity discrimination and pattern vision seem to be demonstrable in animals without the striate cortex in circumstance of increased gradients in retinal illumination, it is assumed that the subcortical visual pathways in the cat and other mammals are differentiated to such a degree as to mediate responses correlated with both intensive and patterned differences in stimulation.

10. The main function of the striate cortex, as indicated by the present experiments, seems to involve the neural control of responses correlated with reduced gradients in retinal illumination either in respect to intensity or pattern vision The separation of visual functions between the striate cortex and the subcortical visual centers seems to be one of degree rather than of kind

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STUDIES OF THE GRASPING RESPONSES OF EARLY INFANCY: I *

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Conflicting reports (21) of the nature and strength of the grasping reflex in human infancy led to a more or less exhaustive examination of this early response The study was conducted on infants at the hospital of the State Farm for Women at Niantic, Conn.[1]

Specifically, the investigation sought to determine the conditions under which the early grasping response occurs Responses to different kinds of objects, i.e., wood, iron, hair, rod of nails, etc., which were placed against the palm, were obtained to determine preferential and shunned materials Responses to contact pressure, strong pressure and "pull" were compared. The strength of the "clinging" response was determined for the individual fingers, for each hand, and for both hands simultaneously The nature of responses by fingers and hands to a yielding object and the amount of pressure exerted in each instance were investigated The relation of hunger and satiation to the grasping response was studied by noting the changes occurring in gripping pressure before, during, and after feeding periods

What is meant by the grasping reflex? Is it the closing of the fingers upon an object in response to palmar contact? Is it the gripping[2] of the object—a proprioceptive response evoked by the

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[1] The writer greatly appreciates the interest and cooperation of Miss Elizabeth Munger, the Superintendent, who set aside a research room and arranged for numerous conveniences which greatly facilitated the study The writer is also indebted to Miss Elsie Shearer, Assistant Superintendent, Dr. Freitag, the Resident Physician, and the nurse in charge of the infants Mrs Josephine Doyle Krynine, graduate student at the Yale Clinic of Child Development, assisted the writer in the experimentation Suggestions by Dr Raymond Dodge of the Department of Psychology, Yale *University, were extremely helpful in carrying on the investigation*

[2] An infant may close his fingers upon an object without gripping it Gripping and clinging here are actually synonymous terms. When an infant grips an object he clings to it In this paper gripping becomes clinging when the object grasped is pulled by the experimenter

introduction of external resistance to the flexors of the hand? Or, is it the combination of these two reactions? The presence of these components, (21), closure and gripping, greatly complicates the early grasping pattern. If complete closure of the fingers to palmar stimulation is a grasping response, any partial or feeble closure to the same type of stimulation is a grasping response However, it is likely that in most cases investigators do not record finger flexion as a grasping response unless full flexion takes place Again, it is likely that other investigators do not record finger flexion as a grasping response unless the object (stimulator) is gripped. They have most certainly observed discrepancies in readiness, speed, magnitude, and strength of early grasping responses and in some cases have reported them.

In dealing with the strength or duration of the grasping response, it is always the proprioceptive reflex which is measured The infant clings to a rod, supporting his weight for a certain period of time It is necessary to refer to this reaction as the clinging response for the following reason If a supine infant is grasping a rod with his hand above him at arm's length, an upward pull on the rod by the experimenter will be resisted by a tightening of the infant's fingers. A weak pull will be resisted by finger flexion the strength of which is somewhat greater than the force of the pull; a strong pull will be opposed by a correspondingly stronger tightening of the fingers. In any event, insofar as the force of the pull is within the infant's immediate capacity to resist it, any attempt at removal of the rod (extension of the fingers) will be more than counterbalanced by finger flexion This fact is clearly demonstrated in one of the present experiments. The posture of the arms in hanging by the hands from a rod is similar to that above. In supporting the entire weight of the body in clinging the infant demonstrates the principle of opposing the force of the "pull" with a greater force by the resisting flexor tendons

Early grasping responses vary greatly in temporal and physical pattern for the individual under conditions which are apparently unchanged A form of stimulation which evokes weak grasping may upon second application evoke strong gripping Similarly, a strong grasp may be followed by a weak closure Then, again, no grasping response may occur The strength of the grasp varies during the day, and from day to day for no apparent cause. The hand may close quickly at one time and slowly at another time The amount of stimulation required to evoke the response is not constant. Grasping may or may not function during sleep. Some of the conditions under which this variable response operates are herein reported.

Other difficulties confront investigators of the early grasping response. In the first place the flexors are the dominant muscles in infancy It is common knowledge that the hand of the very young infant is usually closed and that gradual extension of the fingers is a function of age. Investigations by Swan (49), who has studied the posture of the resting hand of infants, and the normative work at the Clinic of Child Development at Yale (17) confirm this view. Thus the volar surface of the hand, the place of application of the stimulus for evoking the grasping response, is often closed to experimentation. There probably are biological advantages in a closed hand in infancy aside from remote ancestral clinging. A closed hand of the helpless human protects the sensitive palm and at the same time greatly reduces the chances of injury from external sources. The investigator must resort to force to open the hand for the insertion of the stimulus or wait patiently for the infant to relax his fingers Then there is the difficulty of controlling the intensity and area of stimulation under these conditions The lack of control of these factors renders incomparable results—i.e., a stimulus of one intensity yields a certain reaction, a stimulus of different intensity may yield a different reaction. Experiments herein reported show that such is the case Other conditions which may influence the response are: fatigue, nutrition, adaptation to stimulation and so on. Angelis (2) also calls attention to these difficulties in connection with his work on reflexes.

DATE OF APPEARANCE

There is pretty general agreement that the early grasping response is present at birth Among the investigators who contribute to this view are Robinson (41), Mumford (35), Peterson and Rainey (37), Watson (53), Bryan (6), and Hurlock (23) Jersild (27) carefully states that most infants exhibit this response early in life Angelis (2) says that almost all reflexes are ready for operation at birth. Givler (18) believes the response is not only present on the first day of life but that it probably was practiced before birth For Holt (22) the grasping reflex is an example of proprioceptive learning in the fetus. Peiper's (36) view is that the grasping reaction is one of the great array of defense reflexes with which the child is born.[3] Bolaffio and Artom (5; 12) find that reflex grasping occurs in fetal life. Feldman (13) says that all movements at birth are reflexes and that incomplete development of the inhibitory centers accounts for their exaggeration Lenz (31), whose interest in reflexes lies in their influence on the behavior of the individual, thinks that grasping in combination with sucking occupies a signficant place in the development of conduct

In addition to the usual flexion of the fingers in response to tactual or proprioceptive stimulation of the palm or tendons of the hand, smaller contractile (micro-kinetic) finger movements take place at irregular intervals According to Feldman (13), these movements are probably somewhat inhibited at 3 months and quite under control at 3 years. Just what relation these slight spontaneous finger movements bear to the early grasping response no one knows. Both involve finger flexion, in one case the activity is almost continuous but abbreviated, while the stimulus is unknown. In the other case, the activity occurs under conditions of cutaneous or proprioceptive stimulation, or both, and usually involves considerable, if not complete, flexion of the fingers.

Inability to distinguish between reflex and voluntary action in grasping further complicates investigations on the early grasping response. It is probably true that the grasping reflex gradually disappears[4] as voluntary grasping appears and develops. Is the fact that an infant closes his hand more or less immediately on an object placed against his palm a sure indication of the presence of the grasping reflex? Or, does the manifestation of clinging to an object serve as the criterion for the presence of this response? In either case there are many instances wherein neither of these criteria suffice definitely to demarcate as reflex or voluntary the action which takes place. Later discussion will bear on this point

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[3] As for infra-humans, Lashley, K S, and Watson, J. B (30) report that the Macacus rhesus monkey clings to its mother at the start of life, and Jacobsen (25) notes the occurrence of this response in a baby chimpanzee soon after birth

[4] Disappearance of the reflex does not necessarily signify that it ceases to exist, but that it fails to occur under conditions which generally are effective in producing it in infancy

Generally, in reflex grasping the object has to be placed in the *infant's hand, in voluntary grasping the infant can reach* (*in* the early stages incipiently) for the object before he takes it. In its early development voluntary closure greatly resembles reflex closure The object is held principally by the ulnar fingers. Later as the thumb and forefinger express themselves in digital manipulation no doubt exists concerning the fundamental nature of the action. Granted that the very earliest grasping responses are reflexes, before these responses are completely voluntary, there must of necessity come a time wherein the component movements which constitute the total response are in part reflex and in part voluntary. It is at this stage that inability to distinguish the presence or absence of the grasping reflex in individual cases is most apparent.

Wood-Jones regards the hand as the "feeler" of the human organism. With its wealth of cutaneous end-organs this distal portion of the upper limb is to man what the nose is to the dog Just how sensitive is the hand to touch in early infancy is a matter of conjecture (12; 19), although Peterson and Rainey (37) say that the *hand of the very young infant is ordinarily sensitive to light pressure* stimulation with a camel's hair brush.

Our experiments show that infants of a few hours respond to light contact from a camel's hair brush But the human hand also contains a wealth of proprioceptive end organs (19) which are of great importance to the individual in all forms of manual exercise If the reaction hypothesis, that all forms of human behavior are reactions to definite stimuli, holds, responses of the hand due to cutaneous stimulation of the palm should differ from responses which are the result of proprioceptive stimulation of the tendons and joints of the fingers. Similarly, proprioceptive responses from a weak and from a strong pull against the flexors of the fingers should be unlike, because "it is probable that all tension receptors are not affected simultaneously by a small pull, but that increase of pull adds to the number of end-organs involved—'recruitment' at the periphery" (9, p 47)

In an earlier paper (21) certain difficulties in the study of the *early grasping response* are noted The total response pattern commonly consists of a two phase activity, i.e, closure which is the larger movement of flexion of the fingers toward the palm and gripping in which the fingers press firmly against the palm In simple closure the fingers flex until they come to rest near or against the object within the palm If gripping follows, the object is held with a force out of proportion with that required for merely holding the object These two phases of the grasping response are often qualitatively discontinuous and are frequently separated by a definite time interval. Closure is probably the response to cutaneous stimulation of the palm Gripping is the proprioceptive response to strain imposed on the flexor tendons of the fingers.

Disappearance of the Grasping Reflex

Most writers assume that the grasping reflex disappears within the first half year of life (53, 38, 23, 27, 10, 1). Usually four months is given as the time of disappearance. What are the criteria by which the presence or absence of the reflex is determined? The grasping reflex is regarded by many writers as having disappeared if the infant no longer responds by closing the fingers reflexly upon stimulation of the palm. The method of placing a rod or finger within the palm of the infant is commonly employed in eliciting the reflex. If the infant clasps the inserted rod or finger, the reflex is present; if no closure takes place, the response is absent. The criterion used by Watson (53) is clinging If the infant clings to a rod placed in his hand the grasping reflex is present The absence of this proprioceptive response signifies that the reflex has given way to the habit of manipulation Richter (40) employs this technique with monkeys He not only finds a marked variation in the strength of clinging in day by day tests but discovers that the reflex is not as strong at birth as at a later period, i e, 15 to 38 days. The data of disappearance for five monkeys varies from 41 days to more than 83 days For some investigators the presence of established voluntary movements of the arm signals the disappearance of the grasping reflex Darwin (10) notes that at 114 days the infant not merely grasps his father's finger but manipulates his (the infant's) hand so as to bring the parent's finger into a favorable position for sucking. Givler (18) states that the reflex undergoes modifications until the child can do an infinite number of things with his hands. For Watson (53) reaching for an object is coincidental with the disappearance of the grasping reflex. On the other hand Sherman and Sherman (46) find that voluntary movements toward the chin (a preferential direction) reach a fair degree of accuracy very early in life, whereas Krynine (29) finds incipient reaching movements at 12 weeks in infants who still strongly manifest the grasping reflex Watson (53) and Wagoner (51) report that the grasping reflex persists for a longer time in defectives than in normal children. Lashley and Watson (30) note that a young monkey of one week of age reaches for an object and the movement is more precise in the second week The indications are that the grasping reflex is still present Richter's (40) monkeys probably had well developed reaching movements before this reflex disappeared

Thus it is likely that the grasping reflex functions even after voluntary movements are well advanced Bernfeld (3) expresses the view that this reflex, while more or less dormant, is present throughout life Infants over six months of age often display grasping which has all the ear marks of a reflex response Sometimes persistent efforts at palmar stimulation are required to elicit reflex grasping in young infants. Persistence with older infants also brings about a similar grasping response In passing, the assumption that the reflex is gone at six months probably influences investigations. The experimenter in attempting to evoke reflex grasping in infants older than six months does not persist in his efforts as he does with younger infants. If the younger infant does not respond at once to the customary stimulation, the experimenter, knowing the reflex must be present, continues his efforts until some form of grasping occurs; whereas continued persistence with the older infants may also eventually call forth the response. When under these conditions, grasping does occur, is it a reflex or voluntary activity? On the other hand, if the response under discussion is a reflex, probably it should in any case occur readily under similar conditions of stimulation. However, experimentation shows that the grasping reflex is not invariably present even in very young infants Conditions which may determine its absence or dormancy at times will be discussed in a later portion of this paper.

Records show that many infants over six months of age will cling with both hands to a rod or nurse's fingers with sufficient strength to support their own weight for several seconds If this clinging is a true manifestation of the grasping reflex, then the reflex is present long after voluntary arm and hand movements are well established Jacobsen, Jacobsen and Yoshioko (25) find that the baby chimpanzee shows no apparent diminution of gripping strength in clinging throughout the duration (52 weeks) of their study of Alpha. Now clinging during the second half of the first year of life may not be a reflex activity for the human infant. The human infant is not required to cling, to hang on. He is so well cared for that he is given no opportunity for the exercise of this reflex activity. In time this lack of exercise probably accounts for its early disappearance The question may be raised What result would the practice of this function have on its retention?

STRENGTH AND TENACITY OF THE CLINGING RESPONSE

Investigators are at variance concerning the strength and tenacity of the grasping reflex. Robinson (41) reports that at 4 days nearly all of 60 infants sustain their own weights for 30 seconds Most of Watson's (53) infants support their full weight with either right or left hand for periods ranging from a fraction of a second to more than a minute. The fraction of a second probably means that that amount of time was required for slipping off the rod and was not therefore actual grasping time This statement is made in the light of the present investigation Pratt (38) records that a human infant may sustain his weight for 2-½ minutes. Blanton (4) sets the time of suspension at from 1 to 42 seconds while Chaney and McGraw (8) find that the range for time of suspension is 1 to 39 seconds

A number of investigators (6, 35, 28, 27) modestly report that some infants can support their own weights and that the other infants support only the shoulders or the head and shoulders when they are raised from a platform Sherman, Sherman, and Flory (47) find that approximately 10 per cent of infants up to 15 days of age support their weights by either hand and that the left hand is slightly superior to the right in clinging strength. Peterson and Rainey (37) state that some infants hang on strongly enough with both hands to lift head and shoulders. Valentine and Wagner (50) find that no infant can support its weight with one hand In summary then, the strength of the grasping reflex varies from raising the shoulder to supporting the body, the duration of grip in support of body varies from a fraction of a second to 2-½ minutes In contrast to this a chimpanzee sustains its weight by one hand for more than 1 minute (25) and a monkey similarly supports its weight for 33 minutes (40)

Period of Maximum Strength

Is there a period in the early life of the individual when the grasping reflex attains or at least exhibits maximum strength? Is the reflex strongest at birth, does it wax in strength and then gradually wane, is it periodically strong and weak, depending upon the time of day or upon internal conditions of fatigue, nutrition, illness and the like? The general belief has been that the reflex appears in its greatest strength at birth or soon after birth and then diminishes in vigor as voluntary movements begin. Robinson (41) states that the grasping reflex is stronger at 4 days than at earlier periods. Blanton (4) finds the reflex less pronounced at birth than at later periods. In two subjects the reflex is much stronger at 23 days and 52 days than at birth. Bryan (6) reports a weakening of the reflex after the first day or two after which the response appears at full strength. She adds that the reflex is not always evidenced by her infants. Chaney and McGraw (8) discover that the older babies, 1 to 10 days of age, exhibit greater reflex strength than the partunates who are but a few minutes old The suspended grasping times for the two groups are 8 36 seconds and 5.1 seconds respectively. Peterson and Rainey (37) state that some children react on one day and not on another day. In addition, children will react at one time and not at another on the same day. Sherman, Sherman, and Flory (47) find that for 17 infants the reflex appeared to diminish in strength at about 8 weeks Richter (40) finds marked variation in the strength of the reflex in monkeys in day by day trials. The response is present at birth and reaches maximum strength at from 15 days to 38 days. It is apparent that whereas no definite time can be set for the period at which the grasping reflex attains or exhibits its greatest strength, this period probably is several days after birth and varies for individual infants.

Other peculiarities of the grasping reflex appear Infants usually prefer fingers to rods. They grasp yielding objects differently than rigid objects One of Blanton's (4) babies, in whom life is almost extinct, clings strongly to a rod at 10 days. Another baby, dying of malnutrition at 5 weeks, supports her entire weight The reflex sometimes operates during sleep and does not always operate during the waking period (50). The present investigation substantiates these facts. Some children extend the fingers (Babinski-like) and some give no overt response to tactual stimulation of the palm (37) Mumford (35) finds that infants apparently grasp harder with the ulnar than with the radial fingers—a view which the writer has long maintained (20)

Inconsistencies in the strength of the grasping reflex reported by investigators are due to some extent to differences in the size and probably the form of the object used in eliciting this response Watson (53) uses a rod of the thickness of a pencil Blanton (4) uses a rod about ¼ inch diameter Robinson (41) uses his finger at times and at other times a stick about ¾ inch thick Valentine and Wagoner (50) have their infants grip the handle of a special dynamometer Bryan (6) uses the thumb while the Shermans and Flory (47) use a rod 3/16 of an inch in diameter. With a variety of objects such as the above, for determining the strength of the grasping reflex, large differences in results may be expected. The present investigation is in part planned to determine what effect the diameter of the rod has on the strength of the clinging response A second investigation shows the relation between finger length and strength of this response.

Other factors which probably influence the strength of reflex *grasping are: the state of activity of the child, emotional excitement*, hunger, satiation, and desire for physical contact with persons or things

A baby who is comfortably quiet often fails to exhibit any indication of reflex grasping under repeated stimulation of the palm. Even when the fingers are closed on the stimulating object by the experimenter, the baby often fails to maintain his grasp. On the other hand a physically active baby seldom fails to grasp an object presented against the palm The duration of the grasp may be long or short. An emotionally upset infant is not likely to respond in any definite manner to palmar stimulation Withholding the bottle at feeding time will often cause crying and sometimes a physical upheaval which has all the ear marks of rage Palmar stimulation during this behavior may call forth convulsive flexion and extension of the fingers, withdrawal, pushing away, or strong grasping, or combinations of these reactions Blanton (4) has difficulty in eliciting reflex grasping from a quiet baby but no trouble in obtaining this response from an angry, crying baby Dennis (11) believes that crying increases the strength of the grasping reflex, a view which is later corroborated by Sherman, Sherman, and Flory (47)

The state of activity of an infant is often affected by internal conditions such as pain, hunger, satiation and fatigue. Pain and hunger usually evoke, or are accompanied by, crying and strong physical activity. Satiation, fatigue and sleepiness are usually marked by decreased activity. An infant who is fully fed or fatigued is likely to be quiet, if not actually sleepy. He does not readily respond by grasping objects placed against his palm Records of tests made on 11 infants under 16 weeks of age show that just before the feeding period all of the infants grasped a rod touched lightly to the palm and that immediately after feeding 5 of them grasped the rod, 3 closed lightly on it and 3 kept their fingers in relaxed extension.

Johnson's (28) opinion is that hunger probably reinforces the strength of the grasping response Major (33) notes that his child grasps more firmly during the nursing activity. Blanton (4) indicates that in general babies grip harder before and during the nursing period than after feeding. It is likely that peculiarities of the grasping reflex, such as its presence at one time, absence at another time, and variations in its strength, would be better understood, if records of the time of testing for the response and the time of feeding were available. The evidence is that physiological changes within the infant and changes in the external situation both account for these great variations in the functioning of the early grasping response Investigations should aim to eliminate as far as possible the factors, i.e., illness, fatigue, satiation, sleepiness, etc., which are known to preclude effectual elicitation of the response. Then the effects of each of these factors upon the response should be studied.

This paper takes the position that grasping is an activity which is not confined to the hand There are times when infants grasp with the mouth and with the wrists (19). The feet and legs enter the prehensory picture and in fact the entire body at times concentrates upon the object of grasp and attempts to close on it. Thus grasping by the hands is part of a total dynamic corralling pattern which leads to closer contact of infant to object. Contact is unquestionably more or less associated with the acquisition of food

Our records show that for breast-fed babies grasping (convulsive or sustained) is especially strong just when the mother with the child in her arms is baring her breast for the feeding In this case the situation is a complex of contact, hunger, sucking, odor, taste, and probably warmth. In passing, attention is called to the fact that infants who have attained the age (about 16 weeks and older) wherein they are capable of distinguishing familiar people from strangers will cling to the former and often withdraw from the latter. Jacobsen (25) states that the desire for contact with its mother's body may account for clinging in the chimpanzee

From the evidence at hand (2, 6, 7, 37) no racial differences are reported with respect to appearance, strength and disappearance of the grasping reflex.

Investigators of the early grasping response have placed emphasis on its readiness and the strength of the "stretch" reflex of the fingers. They have entirely neglected the phenomenon of release When an infant immediately flexes the fingers upon an object placed against his palm, the activity of closure is referred to as reflex grasping. When an infant supports his weight, in whole or in part, by hanging onto a rod by a hand, such holding is also referred to as reflex grasping. The fact that an infant cannot voluntarily extend the fingers to release an object in the hand has been entirely ignored

At 24 to 28 weeks an infant can reach and grasp an object placed before him However, he can only with great difficulty release it Occasionally he pulls the object out of one hand with the other, but he cannot drop it. Finally a stage is reached when he can release the object against a resisting surface Records (20) show that voluntary release makes it appearance between 36 and 48 weeks and is only well developed after the first year (14, 16) The main point of this discussion is that there is a stage in prehensory development during the second half of the first year when an infant can voluntarily flex the fingers but cannot freely extend them. The situation then is one in which the infant clings to the object because he cannot release it. A pull on the object serves only to tighten the grip A very strong pull may result in full suspension of the infant The inability to release accounts for the late disappearance of the early grasping response

REFLEX GRASPING OF DIFFERENT MATERIALS

The purpose of the first experiment was to discover whether or not babies grasp objects indiscriminately. Probably there is preferential grasping in the case of certain substances, such as hair. Perhaps objects with rough surfaces evoke some form of rejection response.

The experiment consisted of pressing rods of different materials against the palm of the supine infant The rods, 10 cm long and about 1 cm. in diameter, were. smooth wood, rough wood, smooth iron, coarse metal screw bolt, very soft rubber capsule, hair, and rod of nails. The last rod consisted of a wooden cylinder into which were driven in haphazard manner over its surface 100 ½ inch #20 brads The round heads of the brads projected about 3/16 of an inch out of the wood. All objects were of room temperature

When the hand was open the rod was pressed firmly against the volar aspect of the hand at any point between mid palm and finger tips When the hand was closed the experimenter gently but firmly extended the fingers and held them for about five seconds He then applied the rod against the palm, as in the instance of the open hand, and at the same time released the fingers In evoking grasping no attempt was made to control the position of the hand, pressure of the rod, or amount of stimulation The rod was released by the experimenter as soon as the fingers flexed on it. The method of presentation of these rods should not be confused with light pressure stimulation In many instances the arm was in motion or began to move as the rod was presented Under these conditions it was impossible to maintain an unvarying pressure with the rod Inasmuch as increase in activity and in pressure both facilitate reflex grasping, (p 391) more of these responses should occur in the present experiment than in the experiment with light pressure stimulation.

Complete records of the manner of grasping the rods with left and right hands were made on infants ranging in age from birth to 24 weeks The records show that with the exception of the rod of nails infants grasped all rods in about the same manner If the infant grasped one rod, he grasped all rods If he failed to grip one rod, he exhibited this disposition (failure) with respect to the other rods Outside of the fact that infants of 20 weeks or older were inclined to look at the rods before grasping them the only

TABLE 1

MANNER IN WHICH INFANTS ACCEPT SMOOTH ROUND ROD

Age	No of cases	No. cases in which both hands of the infant merely close on the rod	No cases in which both hands close on and grip the rod	No cases in which the *R* hand closes and the *L* hand grips	No cases in which the *L* hand closes and the *R* hand grips	No cases in which *R* hand merely closes on the rod	No cases in which *L* hand merely closes on rod	No cases in which *R* hand both closes on and grips rod	No cases in which *L* hand both closes on and grips rod
0	13	4	3	2	4	6	8	7	5
4	13	0	8	2	3	2	3	11	10
8	11	5	4	0	2	5	7	6	4
12	12	3	5	2	2	5	5	7	7
16	12	0	9	1	2	1	2	11	10
20	14	4	5	4	1	8	5	6	9
24	14	3	7	1	3	4	6	10	8
28	4	1	3	0	0	1	1	3	3

differences noted were concerned with the strength of the grip. Occasionally an infant gripped one object more firmly than he gripped another

If, then, (omitting for the time the rod of nails) there is no *preferential grasping, how do infants accept a proffered rod?* A complete summary of the manner of acceptance of the smooth rod appears in Table 1. The age of the infants, the total number in each age group and the number who grasp in a given manner (listed at the top of the table) are given Inasmuch as the distinction between closure and gripping was discussed in the introduction all items are self-explanatory

The results show that infants of the ages examined grasped objects lightly or firmly according to the method outlined above In about one-half of the cases the right and left hands grasped in like manner; *in one-half the cases one hand closed lightly and the other grasped firmly* Exceptions to this rule appeared at 4, 12 and 24 weeks Later records show that some infants on the first day of life did not always grasp an object placed against the palm Other investigators (37) also report similar results Some infants did not hold objects with a steady grip The fingers alternately loosened and tightened several times These movements were sometimes slow, sometimes fast, and sometimes clonic in character.

The next step, exploratory in nature, was to see what changes in firmness of grip occurred when the experimenter pulled upward on the gripped rod. The pull was tested in two ways: a very slow, steady pull and a quick jerk The slow pull preceded the jerky pull for half of the infants at each age. The order of pulling was reversed for the remaining infants. Table 2 shows subjective

TABLE 2

INTENSITY OF INFANT'S GRIP AGAINST UPWARD PULL OF ROD

		Age in weeks						
	Reactions	0	4	8	12	16	20	24
Pulling slowly on rod	Tightens strongly	1	0	0	1	1	0	1
	Tightens much	4	9	6	6	6	5	5
	Tightens little	3	2	2	4	3	4	2
	No change	5	2	3	1	2	4	6
Pulling quickly on rod	Tightens strongly	3	8	5	7	6	4	5
	Tightens much	4	3	4	3	3	4	5
	Tightens little	2	2	2	2	3	3	3
	No change	4	0	0	0	0	2	1

judgments of the strength of infants' resistance to a pull on the rod. The pull was always directed against the terminal joints of the fingers. In general, the jerky pull evoked stronger gripping than did the slow pull At each age level there were from 2 to 6 instances in which the slow pull failed to elicit any increase in gripping strength, whereas jerky pulls only infrequently failed to elicit stronger grasping. In all cases wherein pulling failed to elicit an increase in strength of gripping, the grasp on the rod was loose The order of pulling did not affect the results

A further series of tests with the smooth rod gave results which bear on the early grasping response. Placing the rod against the dorsum of the closed fingers elicited infrequent opening of the hand by infants of 16, 20 and 24 weeks Pressing the rod transversely along the thenar-hypothenar line of the closed hand gave rather indifferent results With the exception of new-born infants, opening of the hand occurred infrequently at all ages, and, in some instances, was followed by closure on the rod Pressing the grasped rod strongly against the palm of the closed hand also evoked indifferent responses In most cases no change in hand posture occurred. Repeated opening and closing of the fingers and loosening of the grip on the rod comprised the remainder of the responses.

In contrast to reactions obtained from palmar stimulation by all other rods, explorations with the rod of nails gave sufficient evidence of differentiation of response to warrant further investigation. The experiment consisted in stimulating the right palm of the infant first with the smooth rod, then with the rod of nails and then again with the smooth rod Repetition with the smooth rod served only as a check on the results. Only infants who grasped the smooth rod were given the second rod The purpose of the experiment was two-fold: (*a*) to investigate an infant's capacity to discriminate between near-harmful and harmless stimuli, and (*b*) to observe the nature of attempts at avoidance of the near-harmful stimulus Preliminary trials with adults indicated that forceful gripping of the rod of nails produced dull pain. The hands of infants who gripped the rod strongly showed no traces of skin abrasion

It is just possible that to a certain extent the differences between reactions to the two rods might serve to differentiate reflex and voluntary grasping For example, any movement (of the hand of the infant) which is the direct result of stimulation by the rod of

TABLE 3

COMPARISON OF EARLY GRASPING REACTIONS TO SMOOTH ROD AND TO ROD OF NAILS

Nature of responses	Smooth rod Age in weeks								Rod of nails Age in weeks							
	0	4	8	12	16	20	24	28	0	4	8	12	16	20	24	28
Grips or holds firmly	13	9	10	10	11	9	12	3	4	3	1	1	2	3	3	0
Holds loosely	0	4	1	2	1	4	2	1	0	3	1	2	2	2	2	0
Holds, waves arm, cries	0	0	0	0	0	0	0	0	4	1	1	2	1	0	2	1
Holds loosely, cries	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0
Holds, waves arm, releases	0	0	0	0	0	0	0	0	0	1	1	1	1	2	3	1
Holds, waves arm, cries, releases	0	0	0	0	0	0	0	0	1	1	1	2	2	3	1	1
Withdraws vigorously and persistently	0	0	0	0	0	0	0	0	1	0	2	1	1	2	2	1
Withdraws persistently and cries	0	0	0	0	0	0	0	0	1	2	3	3	2	1	1	0
Finger movements while holding rod	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0	0

nails and which in any way contributes to retardation or suspension of the normal course of action of the grasping reflex might conceivably be considered at least in part voluntary. If infants of tender age can even partially inhibit this early grasping reaction, a stimulus which produces discomfort or pain in the grasping member is most likely to elicit evidences of such control If an infant grasps the rod of nails tightly and continues this hold in spite of palpable manifestations of discomfort, such as sudden, violent crying, whereas in gripping the smooth rod no evidence of discomfort is observable, it is likely that the infant cannot inhibit the grasping act. If, however, he can release the discomfort-producing rod or relax his grip to the extent that the rod no longer annoys him, either of these acts constitutes an inhibitory movement.

Table 3 gives the comparative results of stimulating the right palms of infants from birth to 24 weeks Reactions to the smooth rod and to the rod of nails are listed in adjacent sections of the table. Infants are listed according to age There are from 11 to 14 infants in each group.

When a rod[1] is placed against the palm of a child, he may grip it, hold it fairly firmly, hold it loosely or withdraw from it Only persistent withdrawals were recorded. In addition he may, after taking the rod, release it, fret, cry, wave the arm, or alternately extend and flex the fingers. After the rod was grasped the experimenter always pulled lightly on the rod to note the strength of the infant's hold.

At all ages the infants accepted the smooth rod by gripping it hard, holding it more or less firmly, or holding it loosely No emotional reactions occurred but movements of withdrawal sometimes appeared before the rod was grasped Reactions to the rod of nails, however, contrasted strongly to reactions to the smooth rod

The number of children may be too few for drawing definite conclusions from the results shown in Table 3 Comparison of the reactions indicates that a number of infants at each age differentiated the rod of nails from the smooth rod in no uncertain manner, and thereby demonstrated a degree of sensitivity beyond that of mere contact This difference was usually expressed in terms of discomfort, i e, fretting, crying, withdrawing and waving the arm violently. At birth 9 of the 13 infants reacted differently to the two rods. The percentage of infants who so responded is too large

ter of chance It was noted that the older infants were
er able to rid themselves of the rod of nails once they
it Freeing the hand of this rod in the jerky, abrupt
cal of infants of less than six months is accomplished in a
way than at 52 weeks (20); nevertheless, the rod left
Reactions such as withdrawing, waving the arm and
hen compared with the more or less commonplace re-
he smooth rod, suggest the possibility of early initiation
ted voluntary activities. Although movements of other
body were not recorded, they were observed to be in
h the movements of the stimulated hand. Records of the
4 infants of 28 weeks are included in the table.

ES TO LIGHT PRESSURE STIMULATION OF THE PALM

palms of supine infants varying in age from birth to
were stimulated lightly first with a camel's hair brush
ith a rod of balsa wood The stimulus was applied only
hand was quiet without regard for its position The
as moved gently against mid palm with no more than
s and the responses noted Only nine infants were tested
ecause at this age hands are seldom open enough for
ulation Of these nine infants only four could be tested
lsa rod without at the same time prying up the fingers—
e which probably would evoke the "stretch reaction"
is experiment was to be avoided. The results which are
Table 4 show that light pressure stimulation often evoked
e in the hand, particularly during the first 16 weeks.
eks withdrawal movements appeared. They increased
to 32 weeks However, responses of varying degrees of
h as finger movements, partial and full closure, alternate
d opening of the hand and gripping, did occur. The
withdrawal responses per age group was much greater
eeks than before this age. The number of gripping re-
lined after 16 weeks and a sharp drop in closure move-
rred after 20 weeks These facts are significant in that
bly indicate the presence of inhibition in finger closure.
control of finger movements was further indicated by
n behavior which occurred at about 20 weeks Previous
vision played no part in grasping responses Now infants

TABLE 4

RESPONSES TO LIGHT PRESSURE STIMULATION OF THE PALM

								Closure		Closure & Gripping	
Age	No of infants	Stimulus	No *response*	With-*draws*	Finger *mvts.*	Partial *closure*	Alternate *flex & ext.*	Stimulus *not seen*	Stimulus *seen*	Stimulus *not seen*	Stimulus *seen*
Birth	9	Brush	2	0	1	1	1	1	0	3	0
		Balsa	1	0	0	0	0	0	0	3	0
4	18	Brush	2	0	1	5	5	3	0	2	0
		Balsa	5	0	0	2	5	0	0	6	0
8	24	Brush	4	0	4	5	5	4	0	2	0
		Balsa	7	0	3	0	2	8	0	4	0
12	22	Brush	5	0	2	2	4	4	0	5	0
		Balsa	4	0	0	1	2	5	0	10	0
16	24	Brush	4	0	3	5	5	4	0	3	0
		Balsa	6	2	0	1	0	7	1	7	0
20	21	Brush	5	1	2	3	4	4	1	1	0
		Balsa	2	3	3	2	1	5	0	3	2
24	22	Brush	2	6	6	2	0	4	1	1	0
		Balsa	1	9	3	2	0	2	4	1	0
28	21	Brush	2	7	4	0	4	0	3	1	0
		Balsa	0	9	4	0	2	1	3	0	2
32	18	Brush	0	10	4	0	0	0	4	0	0
		Balsa	0	9	4	0	3	0	2	0	0
36	11	Brush	0	9	2	0	0	0	0	0	0
		Balsa	0	10	1	0	0	0	0	0	0

began to reject objects which could not be seen as they were presented.[5] Presentation of the stimulus became the signal for the infant to turn his head and regard the stimulus. In spite of precautions to prevent vision there were instances in which infants managed to see the stimulus as it was brought against the palm. (See Table 4 under *Closure and gripping*.) It was also observed that after 16 weeks many of the movements listed under partial closure, finger movements and alternate flexion and extension were *accompanied by withdrawing the hand from the stimulus* In addition there were certain behavioral features which served to distinguish closure from gripping. On light pressure stimulation with the brush, the fingers often closed to a point within ½ inch of the palm and then, upon failure to contact the brush, went to extension This process was often repeated. Frequently the fingers flexed in large sweeping movements which carried the finger tips close to the wrist. Both of these reactions gave the impression of "feeling for" or reaching for the object (See Figure 5A). Closure in these *instances occurred more slowly than in the instance of the rods* used in the previous experiment wherein no attempt was made to stimulate with light pressure. Extended testing with the brush showed that in at least 50 per cent of the grasping instances closure or partial closure (without gripping) was evoked by careful stroking of the palm. It was easier to evoke closure without gripping in infants who were passive or who had just been fed than in infants who were active or hungry. In this connection Peterson and Rainey (37) report that stimulation by a camel's *hair brush met with only indifferent* success in eliciting grasping responses. The results indicate that for about the first 16 weeks closure is almost *wholly reflex in nature and that after this* age it gradually becomes voluntary.

The effect of thickness of the stimulus object on grasping was tested by stimulating the palm of infants first with a cylindrical balsa rod 1 cm. thick, and then with a balsa paddle only 2 mm thick. The results of this test on 47 infants varying in age from

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[5] *It is often difficult to distinguish reflex grasping from voluntary grasping* in some infants at 16 to 24 weeks At one time they will close immediately on an object placed against the palm At another time they will close immediately on the object only when the object is within their range of vision

TABLE 5

COMPARATIVE RESPONSES TO LIGHT PRESSURE STIMULATION OF THE PALM BY BALSA ROD AND PADDLE

		Responses			
No of infants	Stimulus	No response	Closure only	Alternate flexion & extension	Closure followed by gripping
47	Balsa rod (diam 1 cm)	8	12	5	22
	Balsa paddle (thickness, 2 mm)	13	23	4	7

6 to 15 weeks are presented in Table 5. The responses indicate that closure frequently was followed by gripping when the 1 cm. rod was used and that closure without gripping occurred more frequently than gripping when the paddle was the stimulator. Here again it was observed that in the case of the paddle the fingers of the stimulated hand first flexed until their tips were just short of the paddle which lay flat against the palm and then returned to partial extension. In the instance of the 1 cm. rod this same amount of flexion carried the finger tips against the rod and gripping often followed. If the finger tips had reached the paddle, probably gripping would have ensued. Probably the fingers upon palmar stimulation must find something to grip before they will exercise this function. In passing, it may be added that while infants may vary greatly in their responses from moment to moment, some of this variable behavior is undoubtedly the result of failure on the part of the experimenter to control conditions under which stimuli are presented.

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STUDIES OF THE GRASPING RESPONSES OF EARLY INFANCY: II.*

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CLINGING STRENGTH

The apparatus used in measuring the clinging strength of a hand consisted of a spring balance scale from which was suspended a small stirrup with a grasping rod of wood.[6] The balance scale read to 25 lbs. in ¼ lb. divisions. The grasping rod measured 1 cm. in diameter and 10 cm. in length. A rider was attached to the scale in such a manner that it operated with the pointer and registered the maximum pull after the spring was released.

The spring balance scale was also used for testing the clinging strength of both hands together. The small stirrup was replaced by a large brass stirrup. The grasping surface which was covered tightly with cloth tape, was 1 cm. in diameter and 25 cm. in length.

Selection of the rod was made only after careful study. Inasmuch as there is sufficient evidence now at hand to believe that the clinging strength exhibited by infants depends largely on the diameter of the rod to which they cling (see pp. 430-434), it was finally decided that the diameter of the rod should be determined on the basis of finger length. The average length of the middle finger of these infants from birth to 24 weeks is 3.2 cm.[7] Thus infants can just comfortably flex the fingers about a 1 cm. rod without digging or flattening the tips into the palm.

The strength of the clinging response was obtained for each hand and for both hands together. The order of testing was: right hand, left hand, both hands. A rest interval of two minutes separated the trials. In all instances the experimenter first placed the stirrup in the palm of the supine infant and then drew the infant's hand upward

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[6] Sherman, Sherman, and Flory (47) used this type of apparatus. The rod to which the infant clung was much smaller in diameter than the one used in the present experiment.

[7] Anthropometric data on the length of hands and fingers will appear in a later paper.

at arm's length. Inasmuch as infants often flex the fingers over the thumb, uniformity of posture in holding the rod was obtained by having the thumb flexed against the dorsum of the forefinger. Before the infant was lifted, the experimenter made certain that the proximal interphalangeal joints of the three longest fingers were directly above the rod. The stirrup was pulled slowly and steadily upward until the grip was broken. An assistant gave her entire attention to protection of the infant from falling. No infant was permitted to support his entire weight with one hand for more than 10 seconds in any experiment

The experiment was conducted between feeding periods on wide-awake infants At least two hours elapsed after the feeding period before an infant was tested. The work was concluded a half-hour before the next feeding period Crying infants were rejected.

Table 6 shows the mean strength of the clinging response according to age and sex Age, sex and number of infants in each group are indicated at the left of the table The mean weight of infants per group is stated in grams. Mean clinging strength is shown for right, left, and both hands, first in number of grams of weight supported and second in terms of per cent of body weight supported The number of infants who supported their entire weight is indicated in the extreme right hand column The measures on per cent of body mass supported are of as great value as the number of grams supported in comparing clinging strengths of the successive age groups because, while information of the actual clinging strength of the infant is important, the relation of the strength of this response to the body weight (size) of the infant carries greater significance in view of the fact that the amount of weight supported before the critical point in body suspension is reached operates to the advantage of the larger infant (see p. 398)

If the arm of the infant is not in extension when the pull on the stirrup is initiated almost any response may be expected from *0* to maximum strength With full arm extension the clinging response seldom fails to function, and as the strength of this response is always obtained by experimenters under conditions of arm extension there is no good reason why the experiment should not be so initiated (See Figure 5 C and D) In other words, install at once, as closely as possible, the situation as it is at the time the record is taken, instead of progressing through the several stages of arm extension, each

TABLE 6

Mean Strength (in Grams) of Clinging Response According to Age

Age	Sex	No of infants	Average weight (grams)	Clinging strength R Hand	Clinging strength L Hand	Clinging strength Both Hands	% Weight supported R Hand	% Weight supported L Hand	% Weight supported Both hands	No. infants who support own weight
Birth	F	12	3369	1947	1852	2875	57.4	55.1	85.7	4
to	M	7	3483	1960	1879	2770	55.3	53.7	79.4	2
7 days	Both	19	3411	1952	1862	2836	56.8	54.6	83.4	6
4	F	8	3980	2367	2622	3594	59.8	65.1	86.9	3
Weeks	M	5	4088	2427	2268	3464	60.8	56.0	85.8	3
	Both	13	4021	2390	2486	3544	60.1	61.6	86.7	6
8	F	9	4391	2344	2671	2660	54.5	61.9	84.7	4
Weeks	M	3	4936	3144	3138	4337	63.0	63.0	87.3	1
	Both	12	4527	2544	2788	3850	56.6	62.2	85.3	5
12	F	10	4792	2078	2191	4094	44.4	46.5	85.4	2
Weeks	M	2	4990	2212	2665	3771	47.5	56.5	78.5	1
	Both	12	4825	2100	2270	4040	44.9	48.2	84.4	3
16	F	8	5387	2637	2793	4316	48.6	51.6	80.0	1
Weeks	M	5	5313	2631	2291	3606	45.6	42.8	67.8	0
	Both	13	5358	2634	2600	4043	49.0	48.2	75.3	1
20	F	10	5743	2733	3096	4125	47.3	53.5	71.4	2
Weeks	M	4	5883	2722	3204	4409	46.5	54.2	74.7	1
	Both	14	5783	2730	3127	4206	47.1	53.7	72.4	3
24	F	10	6305	2427	2767	4901	38.5	44.0	76.9	2
Weeks	M	4	6769	3828	3601	5336	56.0	53.0	78.2	1
	Both	14	6437	2827	3005	5026	43.5	46.6	77.3	3
28-36	F	21	7120	1868	1971	2839	26.9	28.6	41.6	3
Weeks	M	6	7071	2098	2816	4851	29.5	39.6	68.1	2
	Both	27	7106	1919	2158	3286	27.5	31.0	47.5	5
40-52	F	6	8543	964	1682	1758	11.1	19.5	20.7	0
Weeks	M	6	9508	1039	888	435	11.0	9.7	5.0	0
	Both	12	9025	1002	1285	1096	11.1	14.6	12.8	0

stage of which shows a gradual increase in the strength of the grasp or some other variation in its strength or posture.

Inasmuch as all records of weight and strength were in pounds and ounces avoirdupois, per cent of body mass supported was computed from these records before they were converted into grams Females outnumbered the males at all ages, because of the scarcity of boy babies at the institution at the time of the experiment.

According to Table 6 and Figure 1 the mean strength of the bilateral clinging response increased from 2836 g. at birth to 5026 g. at 24 weeks after which there was a very rapid decline in the strength of the response The mean strength of this response for the right hand increased from 1952 g. at birth to 2544 g. at 8 weeks, diminished to 2100 g. at 12 weeks and then increased again until at 24 weeks it attained 2827 g. The clinging strength of the left hand at the different age levels closely approximated that of the right hand. However, the left hand in general showed greater strength throughout (Table 7) and attained its maximum strength at 20 weeks.

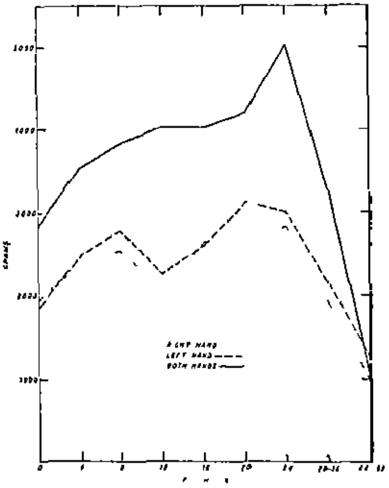

FIGURE 1

Mean Strength (gs) of Bilateral and Unilateral Clinging Responses According to Age

If now the strength of the clinging response is considered in terms of the per cent of body weight supported in bilateral clinging

TABLE 7

Age	No infants	No times clinging strength is greater for Right hand	Left hand	Clinging strength for both hands equal
0-7 Days	19	10	6	3
4 Weeks	13	5	7	1
8 "	12	4	7	1
12 "	12	3	7	2
16 "	13	6	6	1
20 "	14	3	11	0
24 "	14	6	7	1
Total	97	37	51	9

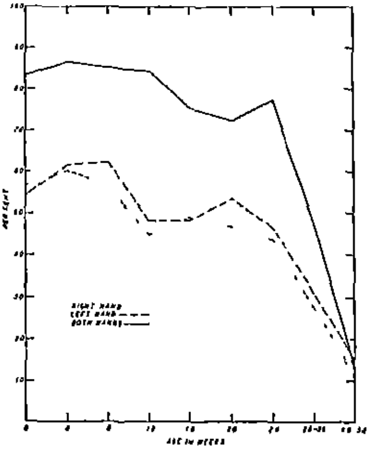

FIGURE 2

Mean Strength of Bilateral and Unilateral Clinging Responses in Per Cent of Body Weight Supported

(Table 6 and Figure 2) infants from birth to 12 weeks supported more of their weight (83 4% to 86.7%) than did older infants. On the whole, infants up to 24 weeks supported more than 70 per cent of their weight with both hands *Up to 8 weeks the right hand* alone supported more than one-half the body weight, and from 12 to 24 weeks more than 40 per cent of it. The left hand generally was somewhat superior to the right in this respect. In all instances diminution in the strength of the response occurred rapidly after 24 weeks

From 28 weeks to 52 weeks some infants failed to react by clinging, others showed vestiges of the response, while a few showed the responses to a marked degree at 36 and 44 weeks Only one infant at 52 weeks gave indication of the presence of the response, a weak cling of 605 gs with the right hand.

The full strength of the response for infants who succeeded in supporting their weight was not determined. It was evident that some of them could have supported considerably more weight than their own mass. Hence the mean strength recorded for each age group, wherein one or more infants supported themselves, must be interpreted as less than the actual mean strength. When the strength of the bilateral clinging response was considered with respect to the number of grams lifted, Figure 1 shows that up to 24 weeks the older infants were superior to the younger ones However, in view of the above statement that the full strength of infants is not known, it is clear that when two infants, one large and the other small, have equal clinging strengths, greater than that required to sustain the weight of the larger infant, then under the conditions of the experiment the larger infant, as far as the record goes, will show to better advantage simply because his body mass more nearly approximates his clinging strength It seems probable therefore that this advantage in strength by the older infants is more apparent than real

Another advantage for the older infant is that a greater weight is thrown on the stirrup before any outstanding change occurs in the posture of the clinging infant The most critical period in support by clinging is the point when the shift in support of the greater portion of the body mass passes from the platform to the hands. As an infant is slowly lifted from the horizontal toward the vertical plane, the shoulders, head, buttocks and finally the feet leave the platform. Now an infant can be raised to the point where only buttocks and feet are on the platform without unduly disturbing him, whereas clearing the buttocks and feet from the platform not only greatly affects body posture but also introduces sway. The amount of body weight to be lifted in order to bring the infant to the point where the buttocks and feet still remain on the platform is greater for the older than for the younger infant and therefore reflects to the advantage of the older infant. In clinging by one or both hands breaking of the grasp usually occurs between the time when the buttocks are beginning to rise and the time at which they clear the platform.

With the older infants enjoying these advantages it is reasonable to assume that per cent of body mass supported is a better measure of the comparative strength of the clinging response at successive age intervals than is actual weight supported.

Bilateral support of the entire body weight occurred more frequently from birth to 12 weeks than at later periods During the first week of life 32 per cent of the infants supported themselves in clinging At four weeks the number who fully supported themselves was 46 per cent, at eight weeks 42 per cent, at 12 weeks 25 per cent, at 16 weeks 8 per cent, at 20 and at 24 weeks 21 per cent, at 28-36 weeks 19 per cent, and at 44-52 weeks 0 per cent Of the 5 infants in the 28-36 weeks group who supported their full weight 3 were 28 weeks of age, 1 was 32 weeks of age and 1 was 36 weeks of age. Neither the manner of acceptance of the rod nor the nature of the clinging differed from that of the very young infants. It is not exactly astonishing to find this response functioning at 36 weeks, when records (20) show that infants of this age experience difficulty in releasing small objects as pellets, 1-inch cubes and balls which they voluntarily grasp. This fact only emphasizes the distinction between closure (flexing the fingers on objects) and tightening (stretch-reflex or resistance to finger flexion).

Of the 97 young infants (24 weeks or less) 27 were able to support their own weights from the 1 cm. rod with both hands. Of the 39 older infants 5 supported themselves Two infants supported their weights when clinging by one hand, one at 4 weeks by the right hand and one at 12 weeks by right and left hands in turn

Advantage in clinging strength was pretty well divided between the sexes (Table 6 and Figure 3) In both unilateral and bilateral clinging the records for all 9 age groups show that the girls led the boys in 13 instances and that the boys led the girls in 14 instances Figure 4 presents graphically the strength of the response by the left hand of girls and boys Inasmuch as the curves for right and left hands are much alike, that of the right hand is omitted. It is noted (Table 6) that for the girls the left hand was the dominant hand at all stages except the youngest age group. Left hand dominancy in clinging strength for the boys appeared only at 12, 20 and 28 weeks Scarcity of records at each age argues against reliability of the results

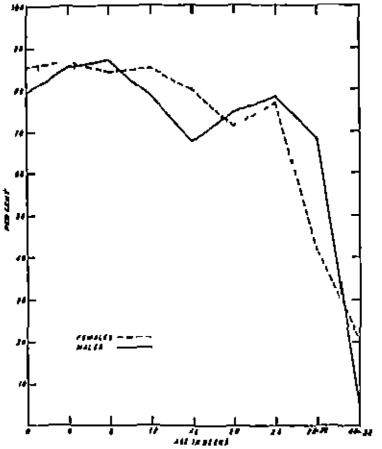

FIGURE 3

Mean Strength of Bilateral Clinging Response in Per Cent of Body Weight Supported According to Sex

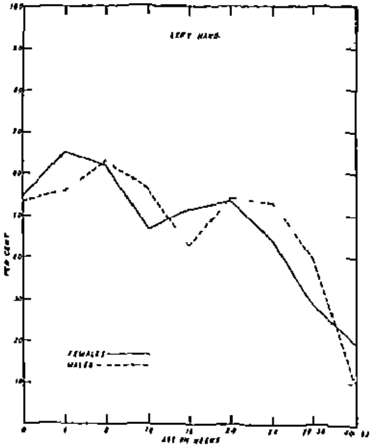

FIGURE 4

Mean Strength of Unilateral Clinging Response (Left Hand) in Per Cent of Body Weight Supported According to Sex

TABLE 8

RANGE OF STRENGTH OF CLINGING RESPONSE ACCORDING TO AGE

Age	Sex	Weight	Clinging Strength (Grams) R Hand	L Hand	Both Hands	% Weight Sustained R Hand	L Hand	Both Hands
Birth to 7 Days	F	2835	1361	1247	1928	37	31	51
		4224	3402	2948	4224	81	78	100
	M	2863	1134	794	1588	33	23	42
		3910	3402	3402	3910	87	87	100
	B	2835	1134	794	1588	33	23	42
		4224	3402	3402	4224	87	87	100
4 Weeks	F	3317	1588	1701	2608	39	45	65
		5216	3742	4196	5216	100	89	100
	M	3402	1474	1247	2495	32	27	54
		4734	3175	3742	4734	86	79	100
	B	3317	1474	1247	2495	32	27	54
		5216	3742	4196	5216	100	89	100
8 Weeks	F	3771	1701	1701	2495	36	36	53
		4990	3175	4196	4479	81	94	100
	M	4366	2268	2495	3742	46	51	76
		5528	4309	4196	5528	78	76	100
	B	3771	1701	1701	2495	36	36	53
		5528	4309	4196	5528	81	94	100
12 Weeks	F	3685	907	1021	3062	18	16	62
		6209	5131	5131	6209	100	100	100
	M	4366	1134	1814	3175	20	32	57
		5613	3289	3515	4366	75	81	100
	B	3685	907	1021	3062	18	16	57
		6209	5131	5131	6209	100	100	100
16 Weeks	F	3997	1701	1588	2835	30	31	67
		6209	3969	4423	5783	64	77	100
	M	4763	1928	1021	2041	40	21	43
		5812	3402	3515	4536	63	68	88
	B	3997	1701	1021	2041	40	21	43
		6209	3969	4423	5783	64	77	100
20 Weeks	F	4961	1361	3161	2495	22	27	45
		6407	5897	4876	6094	97	84	100
	M	5557	2041	2835	3402	34	50	58
		6067	3402	3856	6067	61	64	100
	B	4961	1361	1361	2495	22	27	45
		6407	5897	4876	6094	97	84	100
24 Weeks	F	5783	1588	1474	1814	31	23	29
		6577	2722	2948	6152	47	74	100
	M	6209	1928	1134	3742	28	16	53
		7513	6464	6570	7513	86	75	100
	B	5783	1588	1134	1814	28	16	29
		7513	6464	5670	7513	86	75	100
28-36 Weeks	F	5812	0	0	0	0	0	0
		8108	3856	5330	7569	62	81	100
	M	6719	0	1588	2835	0	23	35
		7484	4196	3969	7080	56	56	100
	B	6209	0	0	0	0	0	0
		8108	4196	5330	7569	62	81	100
44-52 Weeks	F	7995	0	0	0	0	0	0
		9299	3402	4536	6124	39	52	70
	M	8250	0	0	0	0	0	0
		10584	2608	2268	2608	29	22	30
	B	7995	0	0	0	0	0	0
		10584	3402	4536	6124	39	52	70

TABLE 9

MEAN STRENGTH OF CLINGING RESPONSE AND RANGE OF THE MEASURES FOR THE FIVE OLDER AGE GROUPS

Age	No of infants		Weight (grams)	Clinging strength R Hand	Clinging strength L Hand	Clinging strength Both Hands	% Weight supported R Hand	% Weight supported L Hand	% Weight supported Both Hands	No infants who support own weight
28 weeks	12	Ave	6742	2570	2637	4633	38	40	70	3
		Range	5812— 7484	0–4196	0–5330	0–6832	0–62	0–81	0–100	
32 weeks	10	Ave	7453	1327	1814	2322	18	24	31	1
		Range	6917— 8108	0–3402	0–3969	0–7569	0–47	0–56	0–100	
36 weeks	5	Ave	7281	1542	1701	1983	21	24	27	1
		Range	7080— 7853	0–3402	0–3856	0–7080	0–48	0–54	0–100	
44 weeks	9	Ave	8700	1134	1714	1462	13	19	17	0
		Range	7995—10546	0–3402	0–4536	0–6124	0–39	0–52	0– 70	
52 weeks	3	Ave	10001	605	0	0	6	0	0	0
		Range	9299—10584	0–1814	0	0	0–17	0	0	

for the boys However, when the total records of the boys are considered without respect to age, left hand dominancy is indicated

Table 8 presents the range of the weights of the infants by age groups *It also shows the range of the strength of the clinging* response for right, left, and both hands in grams and in per cent of body weight supported. The records indicate that although the strength of the clinging response varied considerably for each of the 9 age groups, on the whole the range of the measures was greatest for the older infants.

Classification of infants over 24 weeks of age into two groups of 28-36 weeks and 40-52 weeks respectively was a purely arbitrary procedure Table 9 shows these older infants in their proper age groups. The number of infants in three of the groups is sufficiently great to give significance to the results which indicate a rapid weakening in the average strength of the early clinging response from 28 to 32 weeks, followed thereafter by a gradual weakening The range of the measures shows that at all ages there were some infants who gave no clinging response. Table 10 shows the nature and frequency of negative responses to clinging.

TABLE 10

NATURE OF NEGATIVE RESPONSES TO CLINGING

	Age in weeks				
	28	32	36	44	52
No of infants in group	12	10	5	9	3
No of infants exhibiting no clinging response	1	2	1	2	2
No. of infants failing to cling when rod is applied to both hands simultaneously	1	5	3	6	3
No of infants failing to cling with 1 hand only	2	3	1	0	1
No of infants failing to cling with either right or left hand alone	1	2	1	3	2

STRENGTH OF THE CLINGING RESPONSE IN THE INDIVIDUAL FINGERS

The apparatus consisted of a spring balance scale of 2000 grams capacity with 25 gram divisions, from which suspended a cord loop For the stronger infants the scale used in the previous experiment was called into service These two balance scales had previously been checked for accuracy. The diameter of the cord was 3/16 of an inch, somewhat less than one-half the diameter of the grasping rod of the stirrup previously used It seemed inadvisable to use a grasping surface larger than the cord. An object of greater diameter not only forced the finger out of line with the others but also slipped too easily from grasp The cord could be placed around a finger without interfering with flexion of the other fingers The procedure consisted in placing the loop around a finger exactly at the terminal joint, extending the arm vertically as in the preceding experiments, and then pulling the loop slowly upward in direct line with the forearm and metacarpals until the finger released the loop. A rider on the balance scale indicated the maximum amount of the resistance of the finger.

Preliminary tests on determining the strength of the fingers in

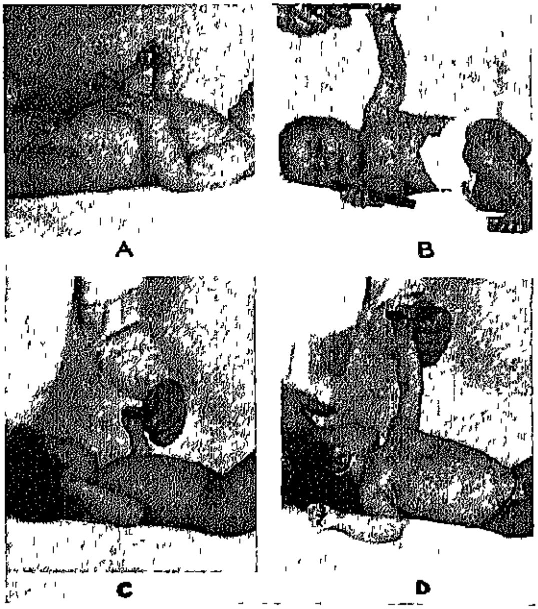

FIGURE 5

(A) Finger closure in response to light pressure stimulation by 15 weeks boy Note extension of terminal joints and aloofness of forefinger (B) Girl infant, 3 days old, lying laterally Both hands grip strongly (C) Boy, 8 weeks, grasping rod loosely before it is pulled (D) Same boy after rod is pulled upward. Note tightening of grip clinging rendered considerable information on the manner in which the fingers yielded under strain. The posture of the entire hand on the stirrup was first observed. The loop was placed at different points along the finger to note the yielding of the joints under the pull. The direction of the pull with respect to the plane of the hand and the effect of the strain upon the infant came under consideration For example, when the loop encircled the finger at the proximal interphalangeal joint a pull on the cord not only pinched the pad of the second phalanx but scraped the finger in slipping. The finger yielded first at the metacarpo-phalangeal joint and then resisted until additional strain forced extension at the other joints The fact that the finger yielded twice indicated a change in leverage which probably jarred the subject. Placing the cord midway of the second phalanx produced equally bad results. When the loop was placed midway of the terminal phalanx and always pulled in a line perpendicular to this phalanx, the proximal joints gave suddenly under the strain, leaving only the terminal joint flexed. Eventually the finger was pulled back instead of up, because the terminal joint did not give until the finger was pulled far back out of line with the metacarpals A pull on the terminal phalanx in line with the metacarpals caused the loop to slip off the finger The most satisfactory place for the loop was at the terminal joint because the two more proximal joints yielded without disturbing the position of the loop. The pull can always be directed in the line of the forearm and metacarpals, which closely approximates the direction of tension in clinging to a rod with one or both hands The thumb presented a special problem. The pull on this digit was directed in a line corresponding to the line of its extension on opening

Table 11 presents in grams the mean strength of the individual fingers for each age group from birth to 24 weeks. The range of the measures from which each mean was obtained appears in the cell below that mean. Age, number of infants of each age, and fingers tested are indicated The mean average strength of each finger for all groups appears at the bottom of the table.

According to this table tests of the strength of the clinging response in the individual fingers show that the middle finger offered the greatest resistance to extension with the ring finger a close second In fact, the ring finger on two occasions, right hand at 8 weeks and left hand at 12 weeks, actually surpassed the middle

TABLE 11

Amount of Resistance (Grams) to Finger Extension

Age	No Infants		Thumb R	Thumb L	Fore Finger R	Fore Finger L	Middle Finger R	Middle Finger L	Ring Finger R	Ring Finger L	Little Finger R	Little Finger L
0	13	Mean	527	475	721	719	1115	1148	985	1098	685	638
		Range	225—950	250—800	200—1425	175—1375	725—1900	675—1775	425—1575	725—1625	125—1025	300—1050
4	13	Mean	465	531	704	829	1369	1410	1327	1308	863	769
		Range	300—825	175—1350	425—1250	125—1500	875—2000	825 1925	850—1900	750—1900	425—1325	525—1050
8	11	Mean	568	530	845	864	1245	1302	1384	1241	900	864
		Range	325—1100	400—725	350—1250	425—1525	875—1950	875—2000	950—1825	875—1975	675—1475	625—1350
12	12	Mean	352	550	425	625	954	1088	902	1144	579	590
		Range	100—825	100—1225	100—825	425—1300	350—1775	425—2050	375—1475	350—2275	275—1125	225—750
16	12	Mean	717	654	806	717	1260	1242	1171	1015	704	663
		Range	225—1425	200—1625	275—1450	200—1300	700—1800	525—2000	525—1925	525—1650	300—1325	300—1225
20	13	Mean	571	712	815	819	1069	1085	900	946	488	629
		Range	175—1225	400—1025	250—1650	325—1275	525—1400	775—1675	575—1325	475—1450	275—700	325—1250
24	14	Mean	641	646	786	897	1139	1212	1046	979	589	688
		Range	300—1125	375—1050	225—1925	425—1350	575—1650	500—1625	350—1575	300—1375	200—1225	225—1300
0-24	88	Mean Average	549	585	729	781	1164	1212	1102	1104	687	692

finger in clinging strength. The forefinger was a poor third with the little finger and thumb following in order. The middle and ring fingers resisted opening with a force so much greater than that exhibited by the others that no one can doubt that these two fingers play the major role in contributing to the strength of the early clinging response of the hand. Figure 6 shows the mean average strength

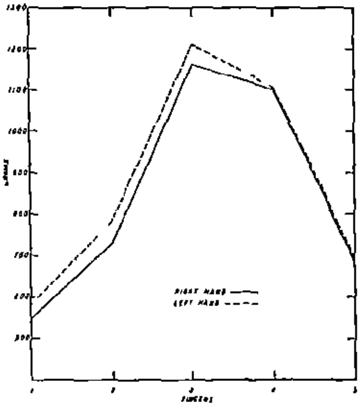

FIGURE 6
MEAN AVERAGE STRENGTH IN GRAMS OF EACH FINGER FOR ALL AGE GROUPS

of each finger for all age groups. The curves clearly indicate the superiority of the middle and ring fingers in clinging strength and show that of the corresponding fingers of the two hands, the left finger in each instance surpassed the right by a slight margin.

Comparison of Tables 6 and 11 shows that the ratio of the clinging strength of the individual fingers to that of the hand is: middle finger 47 per cent, ring finger 44 per cent, forefinger 30 per cent, little finger 27.5 per cent, and thumb 22.5 per cent. Thus the middle and ring fingers each resist extension with a force almost one-half that of the hand, while the other fingers exert a force which is about one-fifth to one-third of that of the hand. However, this comparison is not entirely justified because the clinging strength of the hand and individual fingers were obtained with rods of different diameters.

What explanation may be given for the outstanding superiority in clinging strength of the middle and ring fingers and for the relatively strong resistance to extension exhibited by the little finger.

Judgments of strength are often based on size On this score the forefinger should exhibit a strength closely approximating that of the ring finger The short thick thumb probably should surpass all others in strength. The explanation must lie elsewhere It has already been pointed out (21) that the thumb and forefinger do not always respond in reflex grasping with the three ulnar fingers. Resistance to extension by thumb and forefinger therefore will at times be strong and at other times weak or entirely absent. As a matter of fact this is what the records show On the other hand, the three ulnar fingers lend support to one another in opposing extension. Attempts to straighten one of these fingers is resisted not only by increase in strength of flexion by that finger but also by increased tension of the flexors of the other two fingers The flexor digitorum profundus is the muscle which contracts the terminal joints of the fingers. This muscle mass consists of three parts. One part, the flexor pollicis longus, arises from the radius in the proximity of the elbow and passes to the thumb, another arises from the interosseous membrane between the radius and ulna and extends into the forefinger, while a third has its origin in the ulna The latter part devides in the palm to send a branch to each of the three ulnar fingers. The anatomical arrangement of these divisions of the large flexor muscle explains in part the independence of flexion of the thumb and forefinger and the lack of functional independence of the three ulnar fingers in closing and in resisting extension. It is very probable that, by virtue of this close anatomical connection between the terminal flexors of the three ulnar fingers, a "pull" which evokes the "stretch" reflex in one of the fingers also sets off the "stretch" reflex in the other fingers.

Hand Pressure in Response to a Yielding Object

The purpose of the experiment was to determine how the early grasping response functions when the stimulating object yields to pressure by the hand

The apparatus was as follows. A small sensitive rubber capsule enclosed within a tight-fitting silk sack communicated hydrostatically with the water column of a vertical glass tube. The capsule resembled a hot water bottle and its inflated size was 4 5x1 8x1.5 cm

The silk sheath prevented distention of the capsule beyond these dimensions. A thick-walled rubber tube, ¼ inch diameter, connected the capsule with the vertical glass tube The latter was fastened to a board which could be raised or lowered A paper scale back of the glass tube was calibrated to give pressure readings in 3 g. divisions. (All pressure readings are in terms of gs per sq in)* The height of the water column above the infant's hand in this case (31 cm.) was enough to cause a pressure of 200 gs. within the capsule Thus the infant had to overcome this initial pressure (pressure threshold) before any pressure changes could be observed in the water column To calculate the total hand pressure 200 gs. must be added to the scale readings

The infant lay on a 1-inch thick cloth pad on the table top. Under the conditions of the experiment the infant's arm was extended upward.[8] He was not permitted to grasp anything When he was quiet the capsule was placed transversely against mid-palm so that the tips of the fingers would flex against the capsule When the hand was partially open the capsule was inserted without difficulty When the hand was closed the fingers were opened by the experimenter. No infant attempted to pull on the capsule in an effort to raise himself.

Experimentation required the presence of two persons, one applied the capsule to the infant's hand, the other noted the pressure Records of hand pressure covered a 10-second period A few cinema records were made of the movements of the water column.

The pressure required for complete collapse of the capsule amounted to only 339 grams. Only one infant deflated it and he immediately relaxed his grip. Grasping does not as a rule occur in a jerky or convulsive manner, and, although clonic finger movements occur infrequently during holding, the act of grasping resembles more a tonic muscular contraction.

The manner in which young infants compress a yielding object varies somewhat with the individual and is probably not a function of age at this stage of life. There is, of course, an initial pressure when the fingers first close on the capsule This is usually followed by holding which consists of one or more successive adjustment pressures,

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*These unorthodox pressure readings may be converted into cm H_2O by dividing by 6 46

[8] Inasmuch as postural changes of the arms and trunk probably affect the strength of the grasping response, the arm of the supine infant in all instances was brought to this position

TABLE 12

MANNER OF PRESSING A YIELDING OBJECT

Age in weeks	No of infants	Initial strong pressure followed by continued strong pressure		Initial strong pressure followed by continued weak pressure		Initial strong pressure followed by marked fluctuations in pressure		Initial weak pressure followed by continued strong pressure		Initial weak pressure followed by continued weak pressure		Initial weak pressure followed by marked fluctuations in pressure	
		R	L	R	L	R	L	R	L	R	L	R	L
Birth	13	1	0	2	2	1	5	0	0	2	2	7	4
4	13	1	1	3	4	4	5	0	0	4	2	1	1
8	12	0	1	5	3	1	0	0	0	4	3	2	5
12	11	0	2	3	1	3	3	0	0	3	1	2	4
16	10	0	0	3	4	5	2	0	0	1	2	1	2
20	14	0	1	0	0	3	4	1	0	5	4	5	5
24	12	1	0	1	2	2	0	0	0	2	1	6	9
28	5	0	0	1	0	2	2	0	0	0	0	2	3
All ages	90	3	5	18	16	21	21	1	0	21	15	26	33

Table 12 presents six captions indicating the manner in which infants take and hold the capsule. The pattern of pressure for both hands is shown in their respective columns under the captions *R* (right) and *L* (left).

In eight instances infants closed forcefully on the capsule with a pressure of more than 50 gs. above the threshold and maintained a firm grip throughout In 34 instances strong initial pressure (above 50 gs) was followed by gradual diminution of pressure. In 42 instances strong initial pressure was followed by fluctuating pressure. Weak initial pressure (below 50 gs) was succeeded by continued weak pressure in 36 instances, and by fluctuations of pressure in 59 instances, and by continued strong pressure in only one instance In summary, weak or strong initial pressures were succeeded in most cases by fluctuations of pressure and frequently by constant weak pressure There were few instances of continued strong pressure

No manifest differences in pressure responses of infants of the several age groups appeared and no clear cut distinctions could be drawn between types of pressure by right and left hands

Table 13 shows the distribution of initial pressures by both hands of infants from birth to 24 weeks. Five cases at 28 weeks are included in the table Three pressure levels are indicated. low, 0-40 gs , high, 40-80 gs., and unusually high, above 80 gs

TABLE 13

Distribution of Initial Pressures by Age Groups under Three Classifications, Below 40, 40-80 Grams, and Above 80 Grams

Both right and left hand pressures are included.

Age in weeks	No of infants	Amount of initial pressure above threshold 0-40 Gs	40-80 Gs	Above 80 Gs
0	13	13	12	1
4	13	7	16	3
8	12	11	11	2
12	11	7	10	5
16	10	4	12	4
20	14	17	5	6
24	12	16	7	1
28	5	5	3	2
All ages	90	80	76	24

In general, high initial pressures predominated from birth to 16 weeks After 16 weeks low pressures prevailed. These results may be accidental or they may indicate an inhibitory adjustment in amount of hand pressure to weight or resistance of the prehended object (9, p 130). The records also indicate that in ⅔ of the cases strong or weak pressure by one hand was followed by a correspondingly strong or weak pressure by the other hand.

Peculiarities of grasping the capsule occurred. In many cases the capsule was grasped immediately, in many cases it lay against the palm for a time before the fingers closed on it. Grasping with strong pressure, as well as grasping with little pressure, took place under conditions of immediate or delayed response. In several instances initial grasping was of a 2-level type, i e, light pressure followed immediately by strong pressure

After grasping the capsule the infants held it in diverse ways. Table 14 presents a classification of the manner of holding in terms of successive pressure ranges. There were two instances in which infants gradually relaxed their grip until the pressure reached the zero point. At each age there were infants who maintained a steady pressure (of less than 15 gs. fluctuation) on the capsule. Marked fluctuations in pressure, however, predominated. Sometimes the fluctuations were so irregular with respect to time and amount that further classification was not warranted On the other hand, for many grasps, a succession of two or more definite pressure plateaus appeared These successive plateaus indicate that an infant maintained a more or less constant pressure on the capsule for a time and then readjusted his pressure to approximate a different level. In this way from 2 to 6 well defined levels frequently appear during a single hold Table 14 lists the number of levels which were found and the frequency with which they occurred for the different age groups. No significant correlation between holding pressure and age is apparent. Hand dominance in pressure is not indicated

In summary, infants may grasp a solid rod lightly or with great force In the latter instance the resistance offered by the rod to the flexor tendons of the hand, besides being constant is sufficient to evoke the proprioceptive reflex. In grasping a yielding object the situation is one in which the "give" and "check" of the capsule sets up a rivalry between the physiological forces of contraction and extension The result is an alternate tightening and relaxing of the grip until some more or less permanent adjustment of hand pressure to capsule is established.

TABLE 14

Number of Distinct Successive Pressure Levels Above Threshold

Age	No of infants	Gradual diminution of pressure to zero		Very steady[1] pressure		Fluctuating[2] pressure throughout		2 Distinct levels		3 Distinct levels		4 Distinct levels		5-6 levels	
		R	L	R	L	R	L	R	L	R	L	R	L	R	L
Birth	13	0	1	1	0	1	2	4	3	5	5	2	2	0	0
4	13	0	0	3	4	7	5	1	0	2	3	0	1	0	0
8	12	0	0	5	2	3	5	1	0	1	2	1	1	1	2
12	11	1	0	2	3	4	2	1	0	1	4	2	2	0	0
16	10	0	0	2	3	2	3	5	1	1	2	0	1	0	0
20	14	0	0	2	1	4	4	2	2	2	5	1	1	3	1
24	12	0	0	1	1	2	2	2	1	4	6	1	1	2	1
28	5	0	0	0	0	0	0	0	0	2	1	2	4	1	0
All ages	90	1	1	16	14	23	23	16	7	18	28	9	13	7	4

[1] Steady pressure = less than 15 gs. range

[2] Fluctuating pressure = fluctuating range greater than 15 gs and not greater than 53 gs

FINGER PRESSURE IN RESPONSE TO A YIELDING OBJECT

The foregoing experiment was repeated on the individual fingers because observations on the early grasping response show that the fingers do not close with equal force (21, 35) upon the stimulating object

The apparatus was essentially the same as that used in determining hand pressure. A small cylindrical-shaped rubber capsule, 6 cm long and 8mm in diameter, replaced the hand capsule. This second capsule, also silk sheathed, lay in a semi-cylindrical, copper trough so that when it was inserted longitudinally into the palm only the finger whose pressure was to be determined could press against the capsule. The adjacent fingers in closing flexed past the sides of the trough. The diameter of the capsule was slightly greater than the diameter of the largest finger tip of any infant

The capsule was presented so that the finger when flexed lay in line with the capsule In all other respects the procedure was the same as in the preceding experiment The order of presentation was forefinger, middle finger, ring finger, little finger, and thumb If a finger failed to respond to stimulation (touching the capsule to the palm), the experiment proceeded with the next finger in order until all fingers had been tested The non-responding finger, usually the thumb or forefinger, was then given a second and, in some instances, a third testing Pressures were recorded over a 5-second interval Figures shown in the table were taken when pressure was steady If the pressure gradually diminished, the highest pressure was recorded in the table. The pressure threshold again was 200 gs., hence this amount must be added to the scale readings to obtain the total finger pressure

In Table 15 averages for the age groups show that the middle and ring fingers surpassed the other with respect to amount of pressure exerted. (The middle finger was slightly superior in this regard.) Next in line came the forefinger and little finger, and finally the thumb. Potentially the thumb may be the strongest digit, but it functions with great uncertainty in early grasping. Similarly the forefinger should outpress the little finger, but, inasmuch as this reflex response is principally a function of the ulnar fingers, the results are actually in harmony with predictions (21, 35). Comparison of pressures for corresponding fingers of right and left hands shows a right hand dominance for the 3 ulnar fingers The fore-

TABLE 15

AVERAGE AND RANGE OF FINGER PRESSURE FOR THE INDIVIDUAL FINGERS[9] OF RIGHT AND LEFT HANDS IN GRAMS ABOVE PRESSURE THRESHOLD (200 GS)

Age	No of infants	Measures	Right fingers 1	2	3	4	5	Left fingers 1	2	3	4	5
0	13	Average	3 9	5 1	12.0	7 8	5 1	4.6	5 3	11.3	8 5	4 4
		Range	0-9	0-15	3-30	3-12	3-9	0-12	3-9	6-30	3-33	3-12
4	13	Average	4 8	5 8	9 7	14.1	4 6	5.5	4 8	10.2	9 2	5 3
		Range	0-18	3-15	6-18	6-33	0-24	0-15	0-12	6-33	6-27	0-15
8	11	Average	3 3	5 2	10 4	10 6	5 5	6.0	8 2	10.6	9 8	5.7
		Range	0-9	0-9	3-21	9-18	3-9	0-30	0-30	6-30	3-24	0-12
12	12	Average	2 8	6 5	15 5	12 5	10 0	4 8	4 3	11 8	8 5	5 5
		Range	0-9	0-18	6-30	3-27	0-33	0-15	0-9	6-33	3-21	0-12
16	12	Average	5 3	6 0	11 0	15 8	7 0	5 5	5.5	9 0	7 8	6.5
		Range	0-15	0-12	3-30	6-30	0-18	0-15	0-15	6-15	3-12	0-18
20	13	Average	4 6	5 8	8 8	8 1	4 8	4.6	6 7	10 4	7 6	6 0
		Range	0-12	0-12	6-18	3-18	3-9	3-12	3-15	6-15	3-12	0-12
24	14	Average	3 9	5 8	9 0	8 6	7 1	3.2	5 6	7 5	7 5	4 5
		Range	0-9	0-12	3-18	3-15	0-15	0-9	0-12	0-15	0-15	0-12
Average of the means for all groups			4 1	5 7	10 9	11 1	6 3	4 9	5 8	10.1	8 4	5 4

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[9] The fingers are numbered 1 to 5 from the thumb to the little finger

fingers are evenly matched, while the left thumb apparently functions slightly stronger than the right thumb. Table 15 indicates that, as in the case of hand pressure, there is some evidence of inhibitory adjustment of muscular contraction in the early grasping response after 16 weeks.

On many occasions the thumb and forefinger failed to close. On other occasions fingers closed so lightly on the capsule that no pressure was registered. The number of times that the individual fingers of both hands failed to register pressure was as follows: thumb 45, forefinger 17, little finger 16, middle finger 1, and ring finger 1.

The thumb and forefinger showed a definite aloofness from the other fingers (20, 21). In the case of the little finger failure to press was generally due to weakness of closure. Thumb and forefinger frequently required a second or third presentation of the stimulus for closure.[10] The middle, ring, and little fingers seldom required repetitional presentation.

FINGER PRESSURE IN RESPONSE TO OBJECTS WHICH YIELD TO VARYING DEGREES OF PRESSURE

The preceding experiment was repeated at five successive pressure levels ranging from 100 to 1600 grams in geometrical progression series. Eight age groups of five infants each, examined at intervals of 4 weeks from birth to 28 weeks, served as subjects. The thumb was omitted in this study, because of functional difficulties. In the first place its location and direction of flexion (at right angles to closure by the other fingers) are such as to cause the forefinger and middle finger to interfere with its closure. Secondly, its postural variability makes determinations of pressure by this digit of doubtful value.

Table 16 shows the average pressure of each finger for all age

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[10] The experimenter was often forced to wait for the forefinger and thumb to respond. At times these fingers flexed slowly to contact the capsule and then stopped. Subsequent trials sometimes evoked a response strong enough to register pressure. In any event the statement which best covers the situation is that these fingers may be depended upon to give reactions to palmar stimulation which vary from negative responses to strong gripping. In passing it should be stated that although the early grasping response is still operative for the first 6 months of life, many of the infants at 20 and 24 weeks actually reach for the capsule at its presentation.

TABLE 16

SHOWING THE AVERAGE PRESSURE ABOVE THE THRESHOLD LEVEL OF EACH FINGER FOR ALL EIGHT AGE GROUPS COMBINED AT EACH OF THE FIVE PRESSURE THRESHOLDS

Pressure threshold (Grams)	Fingers of right hand				Fingers of left hand			
	2	3	4	5	2	3	4	5
100	8.1	11.5	10.5	7.8	8.6	11.8	10.4	6.9
200	8.3	10.8	10.4	7.0	7.3	9.8	10.0	4.8
400	5.6	9.8	7.9	4.9	6.7	10.4	8.5	3.7
800	7.8	11.3	10.6	6.4	7.4	9.8	8.8	4.3
1600	1.4	2.7	1.8	0.4	1.5	2.9	2.3	0.4

groups combined at each of the five pressure thresholds. Individual fingers of both hands are designated at the top of the table. Pressure thresholds are shown at the left, and finger pressures in the remaining cells of the table.

As in the previous experiment pressure was recorded in 3-gram steps. However, an exception to this rule was made at the highest pressure threshold which approximates the upper limit of pressure for the fingers. At this level certain infants pressed strongly enough to effect a slight rise in the water column but not enough to raise it to a point 3 grams above the pressure level of 1600 grams. In such instances a pressure of 1 gram was recorded.

At pressure thresholds 100, 200, 400 and 800 grams, the figures in the table indicate the pressure maintained by the fingers after the initial adjustment to the capsule. At the 1600-gram threshold *only one infant was able to maintain pressure above the threshold* level. Therefore the figures for the highest pressure threshold indicate pressures which were only momentarily maintained.

The general pattern of response to the capsule consisted of an initial pressure, usually strong, followed quickly by a period of weaker fluctuating or steady pressure. In most instances the fluctuations ceased at least for a time; in other instances they continued as long as the capsule was held.

Pressure patterns are determined to a great degree by individual differences in the infants. Some infants always maintained a steady pressure on the capsule, others pressed it in a rhythmic fluctuating manner; and many others held it with occasional sporadic movements of contraction and relaxation of grip. Two infants (20 weeks and 24 weeks respectively) always gripped the capsule with great force and at the two lower thresholds maintained this grip with enough pressure to deflate the capsule completely. Increase in general body activity was accompanied by fluctuating reenforcement of gripping pressure, reduction of body activity restored the pressure to its earlier pressure level. At 28 weeks, probably the critical age (19) in the transition from so-called reflex grasping to voluntary grasping, one infant failed (refused?) to close on the capsule with the right hand, although he accepted it readily enough with the left hand. The forefinger again showed a partial functional isolation from the other fingers.

Comparison of the average pressures by each of the 4 fingers for each age group[11] shows that in general the middle finger led all others in amount of pressure at all thresholds with the ring, fore-, and little finger following in succession. In 12 instances the ring finger outpressed the middle finger, in 1 instance the forefinger outpressed all others and in 15 instances the average pressure by the little finger was greater than that by the forefinger. The average of all mean pressures for each finger also shows that the middle finger exerted the greatest pressure on the capsule with the ring, fore-, and little finger following in order.

Although the groups are small in number for comparative purposes, the younger infants, birth to 12 weeks, outpressed the older ones with the exception of the 24-weeks infants. If the means of the pressure averages for both hands are combined, the amount of capsular deflation was slightly greater at the lowest threshold than at the other thresholds. The amount of deflation as shown by the average pressure of all fingers was as follows:

100-gram threshold	9.5 grams
200-gram threshold	8.6 grams
400-gram threshold	7.2 grams
800-gram threshold	8.3 grams

With the exception of the 1600-gram threshold, it may be stated that regardless of the amount of pressure required to deflate the capsule, infants only partially depress it. The corresponding fingers of the 2 hands function with remarkable similarity with respect to amount of pressure exerted on the capsule. It appears then that finger pressure under the conditions of this experiment is a function of the resistance of the yielding object. In other words, the initial resistance to finger flexion by the capsular pressure is generally opposed by a somewhat greater finger pressure

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[11] Limits of space prevent printing of the complete table of finger pressure for the 8 age groups at the 5 threshold levels.

In the instance of the individual fingers, as well as the hand, when the column of water rebounds, a rivalry between the physiological forces of flexion and extension is set up which results in a more or less complex alternation of the two reactions The "give" of the capsule apparently serves as an inhibitor on the flexors just as the "pull" against them in the proprioceptive response serves as a stimulator.

The "give" reaction operates under conditions wherein flexion is weak or strong The low pressure capsule gives easily and inhibition of the proprioceptive response begins at a stage when the strength of the response is not yet at a maximum The high pressure capsule gives only when the strength of the proprioceptive response is considerable Thus, the greater the pressure on the capsule by the flexors, the greater also the inhibitory force to closure.

When finger closure is so weak that the proprioceptive response is probably not evoked, the "give" is restricted to the well padded volar finger tip When the "give" reaches a point at which there is outright resistance to the flexor tendons the "stretch" response occurs Hand closure in response to palmar stimulation does not take place at uniform speed. Fingers at one time flex quickly and at another time slowly under conditions which apparently are similar A slowly closing finger usually carries little force and at times comes to a stop immediately at contact with an object in its path A fast closing finger is almost certain to go to gripping, inasmuch as its speed will carry it beyond the pad-yielding stage into the more effective "stretch" producing stage

HAND PRESSURE BETWEEN AND DURING FEEDING PERIODS

A 5-minute record of hand pressure of 10 bottle-fed infants, 4 girls and 6 boys, was made in the morning at the interval mid-way between feeding periods. Another record of these infants was taken which covered the noon feeding period. The latter record began five minutes before feeding started and continued throughout feeding The bottle was hidden from view during the pre-feeding period. The infants used their customary nipples through which the milk flowed easily. Feeding periods varied in length from 7¼ minutes to 14¾ minutes Records of three other babies who cried during the course of the experiment were not used All records shown are for the right hand

The apparatus for registering hand pressure consisted of the hand capsule, previously described, which communicated by means of a thick-walled rubber tubing, 3/16″ inside diameter, with a water manometer. A float in the manometer recorded pressure on the drum of a kymograph while a time marker recorded 15-second intervals

In all 10 cases the grasping records made during the 5-minute interval in the morning differed so little from the records made during the pre-feeding period that a description of the latter records suffices to cover the grasping reactions at both periods.

Grasping during the 5-minute pre-feeding period was characterized by alternate strong or weak gripping and partial or complete releasing of the capsule so that the pressure above the threshold (200 mm. H_2O) varied between 0 and 166 mm H_2O. The first reaction was usually a strong tonic grip Frequency of contraction and relaxation of grip varied with the infants Some infants opened and closed

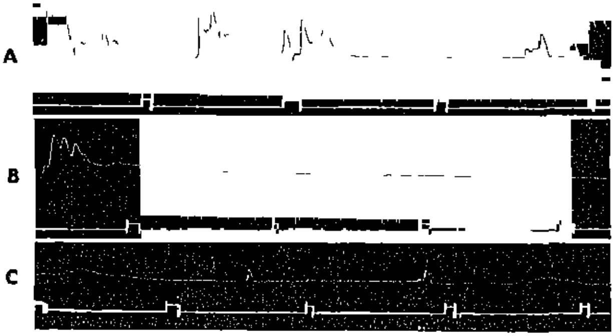

FIGURE 7
Hand Pressure at Feeding Period

Hand pressure of a 10 weeks male infant (A) for 1 minute before feeding, (B) for 1 minute at start of feeding and (C) during the last minute of the feeding period The upper line in each case is the pressure curve, the lower line is the time line marked off in 15 second intervals Sucking was almost constant throughout the 9¼ minutes required for emptying the bottle Note the great fluctuations in hand pressure before feeding begins, the sudden increase as the bottle is presented followed by the rapid irregular decrease during the first 5 seconds of sucking and the more gradual decrease thereafter Note also the relative steadiness of hand pressure throughout the feeding period the hand rapidly (once or twice per second); others tightened and released the grip slowly. The more restless infants contracted and relaxed the fingers rapidly several times and then released the capsule. This process was repeated throughout the period. The others, after gripping the capsule strongly, maintained a low and slowly fluctuating pressure with infrequent partial or complete release. Individual records over the 5-minute period show that the infants at irregular intervals maintained pressure steadily enough to be classified as plateaus (see Figure 7A). Increase in body activity was always accompanied by marked fluctuations in hand pressure at a higher pressure level.

Concomitant with introduction of the nipple there occurred marked fluctuations in hand pressure. The anticipatory opening of the mouth was accompanied by general increase in activity of the body. The rapid changes in muscular tension were reflected in the equally rapid movements of hand flexion and relaxation. These rapid oscillations in hand pressure quickly subsided as sucking became steady and a sharp decline in pressure took place. Table 17 shows the course of hand pressure during the feeding period of each of the 10 infants. The age, sex, duration of the period, and the beginning pressure appear in order. The pressure at the ½ minute interval and, after that, at the end of each successive minute is recorded. Final pressure, retention or release of capsule, and state of rest of the infants at the end of the feeding period complete the table. Records of hand pressures taken at intervals between those indicated in the table show that variations occurred which do not appear above. In general, such variations were small. Renewed sucking usually brought with it a sudden rise in hand pressure which was usually followed by a slow decline until the former low pressure mark was attained or the capsule was released. The curve during steady sucking resembles a plateau (see Figure 7B and C). The records show that for these infants the initial high fluctuation and rapid decline of hand pressure were followed either by steady and relatively low pressure which diminished slowly during the feeding period, or by one or more successive pressure plateaus each of which was preceded by a short irregular rise in hand pressure. In six instances pressure at the end of the feeding period was below the pressure threshold. In four of these instances the capsule fell from the hand; in the other two cases the pressure on the capsule was

TABLE 17

Age in weeks	Sex	Duration of sucking in minutes	Starting pressure in mm H_2O	Successive pressures (mm H_2O) at 1-minute intervals during the sucking period																Final pressure	Capsule finally held or released	Condition of infant at end
				½	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15			
8	F	7¼	78	35	26	17	23	13	13	9	17	13	6	0						0	Released	Asleep
7½	M	14½	82	56	35	9	4	4	4	4	13	9	9	22	13	9	13	9	13	13	Held	Quiet
8	F	10¾	91	35	26	30	22	17	9	22	22	17	17	13	0					0	Released	Quiet
8	F	9¼	26	9	13	13	17	13	9	4	4	4	2	0						0	Held	Asleep
4	M	10	65	30	30	9	13	9	39	26	9	4	13	4	0					0	Released	Quiet
2	M	9	74	30	30	13	4	26	17	9	13	4	0							0	Released	Quiet
9	F	14¾	35	17	17	13	13	9	9	9	0	4	4	0	4	0	0	3	0	0	Held	Asleep
9	M	10½	206	113	61	70	0	74	52	74	30	44	56	44						44	Held	Drowsy
10	M	9	169	83	87	56	35	35	22	9	9	17	9							9	Held	Quiet
18	M	8¾	118	83	35	39	17	48	39	26	17	17	22							22	Held	Quiet

strong enough to prevent its slipping In the four remaining instances pressures from 9 to 44 mm H_2O above the threshold were maintained at the end of the feeding period and in one of these instances the infant was drowsy

It seems clear that a very definite relationship exists between satiation and grasping The physiological condition of the organism at the beginning of the feeding period when the infant is hungry serves as a reenforcing agent to grasping, whereas the state of the organism at satiation apparently serves as an inhibitor to forceful grasping (39, 38, p 173) Thus, at the start of the feeding period the infant clutches strongly at objects within the palm At the end of the feeding period he grasps weakly or not at all. The infant also grasps more readily at the beginning of the feeding period than at the end For example, removal and reinsertion of the capsule evoked instantaneous and strong gripping in the instance of six hungry infants and only occasionally weak and relatively slow finger flexion in the instance of these infants at the end of the feeding period.

The following is a running description of the reaction of the right hand of a 10 weeks male infant to the capsule before, during, and after the feeding period The record began 10 minutes preceding the introduction of the bottle, and continued for 15 minutes after the feeding period. The actual feeding time was $15^2/_3$ minutes.

In the 10 minutes preceding feeding there immediately occurred seven periods of very fluctuating hand pressure ranging from 0 to 148 mm. H_2O Between these periods were intervals of low pressure plateaus, 22-52 mm H_2O. The former periods lasted from 8-15 seconds; the latter from 7-30 seconds Then followed about 6 minutes of low pressure (ave 17 mm H_2O) during which frequent (14) small fluctuations and infrequent (2) large fluctuations appeared.

Presentation of the bottle was accompanied by an immediate increase in pressure to 122 mm H_2O The pressure, at first very fluctuating, sank quickly (with the interruption of one increase) to 56 mm H_2O, after which a slow diminution in pressure brought the level to 36 mm H_2O after 3½ minutes of sucking A long period of low steady grasping followed during which time the pressure varied slowly from 26 to 48 mm H_2O, with minor fluctuations accompanying changes in sucking rhythm, breathing, or body posture

At 12¼ minutes of feeding the pressure fell to 0 and remained there for a time. Finally a steady pressure of 26 mm H_2O was maintained for the last 2½ minutes.

When the bottle was removed the infant retained the capsule with a steady pressure of 17 mm H_2O (ave.) with occasional small fluctuations from 0 to 35 mm H_2O. At times the capsule lay loosely within the palm. However, at no time during the last 15 minutes did he open his hand and drop the capsule.

These comparative records of the amount and course of grasping pressure at intervals between, before, during, and after feeding periods have a distinct bearing on the relationship between the activity of the organism at the time of eliciting the response and its strength.

When feeding takes place without apparent frustration of any sort (i.e., milk flows through the nipple in satisfying amount for the infant), and no external handicaps, such as removing the bottle or shifting his position, are imposed, the infant's movements which at the start of the feeding period are probably induced by the physiological conditions of hunger, diminish in number and amount from a relatively high state of activity to a more or less passive state.

Aside from the immediate physiological changes in the organism due to the transformation from a state of hunger to a state of satiation, a factor which probably contributes to the reduction of general activity and hand pressure is fatigue. A considerable amount of muscular energy is expended in the acquisition of food. Sucking and crying are perhaps the two most vigorous activities carried on by the infant. In sucking the mouth region is not the only part activated. The entire organism partakes vigorously in the assault upon the food supply. The output of energy gradually diminishes as the point of satiation approaches. It appears likely that physiological conditions of fatigue account at least in part, for the gradual reduction in hand pressure during the feeding period. Hunger stimulates the infant to greater body activity which is reflected in increased grasping strength. Fatigue is accompanied by a decline in activity which in the case of grasping is revealed in reduction of hand pressure.

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STUDIES OF THE GRASPING RESPONSES OF EARLY INFANCY III*

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RELATION OF ACTIVITY AND POSTURE TO GRASPING

Can the experimenter by adroit stimulation of the infant's hand evoke at will one or the other of the components of primitive grasping? The answer is that very often the response desired can be evoked.

Consideration of the physiological conditions underlying the grasping situation may aid in the explanation. The state of activity of the infant at the time of stimulation to a great extent determines the nature of the response. These experiments show that the active infant is likely to grasp the rod more tightly than is the quiet infant. The infant who lies quietly, his muscles in a state of rest, differs physiologically from the infant who is constantly in movement, whose muscles are alternately contracting and extending. Especially is this true where arm activity is extensive. The relaxed infant is not "set" for quick reactions or severe exercise of his neuro-musculature, and conversely, the active infant is not "set" for slow reactions or loose grasping. If, therefore, certainty of gripping is sought, stimulate the palm of the active infant. If merely closure is wanted, try the placid infant.

Although posture is largely determined by activity or lack of activity, the position of the hand gives some indication of the type of grasping response which may be elicited. Perhaps the posture (assumed by the infant and not forced upon him by the experimenter) which is most likely to abet loose grasping (closure only) is the hand in the vicinity of the shoulder. With the balsa rod as the stimulus, the experimenter was successful in evoking loose grasping by 31 of 42 infants ranging in age from birth to 16 weeks. In

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other words 74 per cent of the infants responded by closing lightly on the rod while the 11 remaining infants grasped it firmly A follow-up experiment on 13 of these infants showed that continued stimulation by light contact of palm by the balsa rod until four grasping responses had been evoked resulted as follows· In 9 cases wherein closure alone was the first response, all succeeding responses were light closure In 2 cases wherein closure alone was the first response, the succeeding responses were 1 gripping and 2 closure responses. In 2 cases wherein gripping first occurred, the other responses were 3 successive grippings by one infant and 1 closure and 2 grippings by the other infant.

The relation of arm position to readiness and strength of early grasping responses was studied by holding the arm in predetermined positions and then inducing the response. There is sufficient evidence to show that the proprioceptive response, "clinging," induced by suspending an infant by its grasp on a horizontal rod, is generally of great strength Probably this method of evoking the early grasping response best illustrates its force and tenacity Does this response occur as readily and as forcefully when the arms are extended in other directions? Naturally the infant cannot be suspended when its arms are extended down along the trunk or out laterally. The arms of the supine infant, however, can be moved into many positions of extension, and of the possible positions the following were selected

1. Arm extended upward from shoulder
2 Arm extended headward.
3 Arm extended laterally in line with shoulders
4. Arm extended close to side of trunk
5. Arm flexed with hand near ear.

With the infant facing upward, the palm of the hand was touched firmly but not forcefully with the wooden rod and the immediacy and strength of the response noted. If the infant closed his hand on the object, the experimenter pulled on the rod to see if the infant resisted its withdrawal

The 36 infants used in this experiment varied from one day to 24 weeks of age From 4 to 6 infants at each of the following ages were tested: birth, 4, 8, 12, 16, 20, and 24 weeks. Inasmuch as no age differences in the responses were apparent, the results for all infants were combined When the arms were extended upward or headward all infants grasped immediately and held the rod with a firm or very strong grip In lateral extension (arm in line with the shoulders), 5 infants grasped immediately and strongly, 13 grasped at once firmly but not strongly, 4 grasped firmly after a short interval, 11 held the rod loosely after slow closure and 3 failed to grasp. With the arm at the side of the trunk 3 infants immediately closed strongly on the rod, 7 grasped the rod at once with a firm hold, 3 took it firmly after a short time, 8 after extensive stimulation closed the fingers loosely on the rod, and 15 did not close on the rod With the hand near the ear, 15 infants closed at once on the rod. Of this number 4 infants gripped the rod strongly, 7 took it firmly at once and 4 closed loosely on it. Of 17 infants who closed on the rod after continued stimulation, one gripped it hard, 5 held it firmly and 11 held it loosely Four infants failed to close on the rod In general, immediate and strong grasping occurred when the arm was extended upward or headward. Immediate and strong grasping occurred less frequently with the arm extended laterally or at the side or with the hand in the vicinity of the ear. More negative responses occurred with the arm close to the side than in any other position.

In comparing the results of this experiment with those obtained by light palmar stimulation, two facts must be considered. First, the method of stimulation, as stated above, was different, and second, the position of the arm was forced upon the infant in the present situation, while in the former instance the position was assumed by the infant.

Magnus (32) has shown that alterations in postural pattern accompany spatial changes in position of the body These "attitudinal reactions" have been observed in both intact and decerebrate animals Probably one of the best known of these reactions in the human infant is the tonic neck reflex which finds the jaw-arm extended and the occiput-arm flexed Ten supine infants, 3 days to 8 weeks of age, who assumed this posture were tested for gripping When a rod was placed in each of the infant's hands, it was found that for all infants both rods were gripped with about equal strength When these infants lay on their right sides with their heads resting laterally on the platform, 9 of them gripped the rods as strongly with one hand as with the other (Figure 5 B) The 10th infant alternately opened and closed his right hand as he gripped strongly with his left hand. It was only when the infant's grip was strong enough to permit lifting him from the platform by the left rod that the right hand opened with the fingers in rigid extension (Figure 9 C and D) In contrast to these results Fulton (15) finds that the upper hand of a laterally placed thalamic monkey exhibits a strong grasping reflex while the lower hand closes little or not at all

FINGER LENGTH AND CLINGING STRENGTH

Capacity for supporting body weight in clinging is, to a large extent, dependent on gripping posture. Investigation of the posture of the hands in grasping the 1 cm. rod revealed surprising differences in size and shape of infants' hands as well as anomalies in clinging. Hands are wide or narrow, long or short, and thick or thin, just as they are in adults Similarly, differences in finger length and finger diameter are clearly discernible. Examination of two infants of 8 weeks revealed differences in dimensions of corresponding parts as follows

Length of hand	1.3 cm.
Width of hand	0.9 cm.
Length of middle finger	0.8 cm.
Diameter of middle finger	0.4 cm.

Fingers of 3.2 cm. or more in length completely encircled the rod and presented no difficulty in clinging; fingers of 3.1 cm or less in length failed to encompass the rod and thus considerably handicapped clinging An infant with long fingers starts clinging with the proximal interphalangeal joints above the rod. When fatigue overcomes the flexing strength at these joints the distal joints often serve to check an abrupt yielding[12] of the grasp An infant with short fingers clings to the 1 cm rod with the second phalanges or the terminal joints immediately above the rod Thus his grip at the start is a precarious one.

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[12] The fingers yield in no particular order In clinging by two hands there is a gradual yielding of all fingers accompanied by a slipping of the rod toward the terminal joints Then a sudden "break" by one hand At this point the infant is caught and held and the other hand removed

In view of these differences in size of hands and clinging posture measurements were taken of the length and thickness of the middle finger of 97 infants whose ages ranged from birth to 24 weeks. The distance from the proximal to the distal extremity was found by flattening the palm against a transparent millimetric scale.[13] The width of the proximal phalanx of the extended finger was determined by calipers.

The average length of the middle fingers of the 97 infants was 3.19 cm. The circumference of the rod was 3.14 cm. Infants whose middle fingers easily encircled the rod were classified as long-fingered (3.3-3.8 cm.); infants whose middle fingers just about reached around the rod were grouped as medium-fingered (3.1-3.2 cm.), infants whose fingers were definitely too short to encompass the rod were grouped as short-fingered (2.7-3.0 cm.). Table 18 shows this classification. Other items include the number of male and female infants in each group, average weight, average clinging strength in grams for right, left and both hands together,

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[13] This method and a special photographic method are now in use for measuring segments of the body. Measurements thus obtained will be presented at a later date. There are no available records on the length of fingers of young infants. According to Scammon and Calkins (42, p. 224) the calculated length of the middle finger at birth is 3.47 cm.

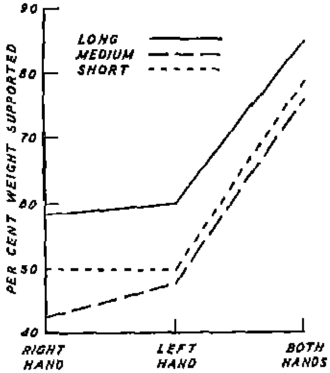

FIGURE 8

Mean Strength of Bilateral and Unilateral Clinging Responses in Per Cent of Body Weight Supported for Long-fingered, Medium-fingered and Short-fingered Infants average per cent of body weight supported in unilateral and bilateral clinging and number of infants who supported their entire weight.

The data show that each infant supported a certain portion of his weight in clinging by one or both hands. The long-fingered infants were superior to the other infants in clinging strength both in grams and in per cent of body mass supported (Figure 8). Table 18 shows that the long-fingered group supported an average of 84.9 per cent of their body mass in bilateral clinging. The medium group supported 76.2 per cent and the short-fingered group supported 78.8 per cent of their body mass in bilateral clinging. The long-fingered group was also superior to the other groups in unilateral clinging. Twenty, or 50 per cent, of the 40 long-fingered infants supported their entire weight in bilateral clinging, whereas only 3, or 12 per cent, of the 26 medium-fingered infants, and 5, or 16 per cent, of the 31 short-fingered infants supported themselves.

RELATION OF DIAMETER OF ROD TO CLINGING STRENGTH

The effect of the size of grasping surface on the strength of the clinging response was determined by having infants cling to rods of different diameters (Figure 9). The first rod had a diameter of 1 cm.; the second a diameter of 3/16 of an inch. With one exception the precautions and method of testing were similar to those used in the earlier experiment in determining clinging strength. In the present experiment the time of testing began two hours after the feeding period and continued to the next feeding period. The infants were first required to cling to the large rod and then, after a three minute rest, to the small rod. The larger rod was used first because it was less disturbing in its effect on the infants. The small rod cut sharply into the palm and often resulted in crying. The hands were always massaged after the 3/16 rod was used. Two groups of infants were tested. Sixty-four infants clung unilaterally (with the left hand) and 62 infants clung bilaterally. The results tabulated in Table 19 show that on the average infants supported more of their weight in clinging to the small rod than in clinging to the large rod. This is true for clinging by one or both hands. Of the 64 infants who clung unilaterally 10, or 15.6 per cent, supported their entire weight from the 1 cm. rod, whereas 33, or 51.6 per cent of them supported themselves from the 3/16 inch rod. Of

TABLE 18

SHOWING CLINGING STRENGTH OF INFANTS UNDER 24 WEEKS OF AGE ACCORDING TO FINGER LENGTH

Finger Length	No. of infants		Distribution of infants according to finger diameter			Mean weight of infants (Gs.)	Mean clinging strength (Gs.)			% Weight supported (Mean)			No. of infants supporting own weight
	Males	Females	Thick	Medium	Slender		Right	Left	Both	Right	Left	Both	
Long 3.3-3.8 cm	18	22	17	8	15	4991	2862	2966	4240	58.3	60.1	84.9	20
Medium 3.1-3.2 cm	5	21	6	15	5	5073	2107	2421	3824	42.5	47.8	76.2	3
Short 2.7-3.0 cm	7	24	6	21	4	4465	2151	2144	3425	50.0	49.8	78.8	5

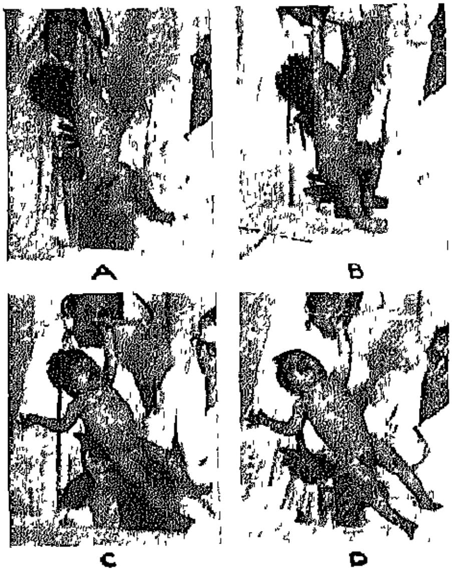

FIGURE 9
BILATERAL CLINGING BY 8 WEEKS BOY (A) TO LARGE ROD, DIAM 1 CM, AND (B) TO SMALL ROD, DIAM 3/16 INCH

Note that left hand grip on small rod is weakening. Note sharp hip flexion Unilateral clinging (C) to large rod and (D) to small rod Note how completely fingers encircle small rod Compare posture in bilateral and unilateral clinging Note especially the rigid extension of the fingers of the free hand in unilateral clinging.

the 62 infants who clung bilaterally 20, or 32 3 per cent, supported their weights from the 1 cm rod while 36, or 58 1 per cent, of them supported themselves from the 3/16 inch rod. The average age of the two groups was 10 5 weeks, and 11 1 weeks respectively

Observations by the experimenters and two assistants confirm the fact that infants more easily support their weight from the 3/16 inch rod than from the 1 cm. rod but that the use of the former rod was more frequently attended by crying

A review of the individual results shows that when the left hand alone was used there were 39 instances in which infants exhibited

TABLE 19

UNILATERAL AND BILATERAL GRIPPING STRENGTH IN CLINGING TO RODS OF 1 CM AND 3/16 INCHES IN DIAMETER

	No of infants	Ave age in weeks	Age range in weeks	Ave wt of infants (gs)	Clinging strength			
					1 cm rod		3/16 rod	
					Av. wt supported (gs)	% wt supported	Av wt supported (gs)	% wt supported
Left Hand	64	10 5	1-24	4356	2984	68 5	3287	75 4
Both Hands	62	11 1	0-24	4449	3743	84 1	3848	86 5

greater strength in clinging to the small rod than to the large rod In 9 instances they clung with greater strength to the large rod and in 16 instances clinging strength was equal for the two rods When both hands were used greater clinging strength was indicated for the small rod on 33 occasions and for the large rod on 8 occasions In 21 instances infants clung as strongly to one rod as to the other Thus infants in general clung with greater strength to the 3/16 inch rod than to the 1 cm rod These results are discussed at length later.

DISCUSSION

The investigation sought to answer several questions concerning the early grasping response. Perhaps certainty of grasping depends on conditions inherent in the hand, such as the points stimulated. There is no evidence to support this statement Apparently one point is as effective or ineffective as another in evoking grasping Perhaps size, shape, hardness, smoothness or some other quality of the object is the determining factor in evoking the grasping reflex. The results obtained with the several types of rods show that such is not the case Infants grasp harmless objects indiscriminately Perhaps the weight of the object or the pressure with which the object is applied to the palm affects grasping. Comparison of the results obtained from light pressure stimulation and from stimulation with the rods indicates that the latter situation was more effective in evoking grasping. However, whereas light pressure may be considered as approximately pure tactual stimulation, application of the rods against the palm stimulates not only the skin but the proprioceptors of the deeper tissues Thus in the case of the rods the investigator is not evoking responses to palmar stimulation as such The differential responses which may be expected to result from these two forms of stimulation are discussed fully at a later place.

Light pressure stimulation of the volar aspect of the hand is perhaps the most effective method of evoking the closure response However, this form of stimulation frequently failed in its purpose. The present experimentation with the camel's hair brush and balsa paddle and an earlier study (21) reveal that the hand often remained quiescent or withdrew from the stimulus In fact, closure in response to tactual stimulation occurred more frequently with older infants than with younger infants

Failure to respond to stroking by the camel's hair brush may be attributed in part to a high tactual sensibility threshold in early infancy (19, p. 239) In other words, it is possible that the infants do not sufficiently sense the stroking pressure to respond to it In this connection it is recalled that stimulation with the rod of nails evoked anomalous reactions Some infants cried upon gripping the rod lightly; others cried only when it was gripped firmly or pulled by the experimenter, others did not cry at all even when the rod was pulled strongly by the experimenter

Under the method of presentation of the stirrup no difficulty was experienced in inducing static gripping by infants up to 24 weeks From 28 to 52 weeks failure to grip occurred with increasing irregularity Up to 24 weeks only one trial was required to elicit gripping by either hand After 24 weeks failure to grip was rarely followed by gripping on succeeding trials. Apparently then, the method most likely to evoke gripping is to place the stirrup rod in the palm with one hand and pull the arm up with the other hand, while holding the rod in place Full extension of the arm apparently is resisted by the entire flexor system of the arm. Hence the resistance to extension by the fingers represents only a fraction of the total resistance to arm extension With many infants the clinging reflex was often obtained with the elbow and shoulder at varying degrees of flexion

Clinging by both hands and clinging by one hand are physiologically different situations In the former instance both shoulders are raised simultaneously from the platform in a bilateral fashion, in the latter instance, the infant is raised in a unilateral manner. The trunk rolls away from the direction of the pull so that the arm is abducted at the shoulder The postural change involved in the two types of clinging brings about a shift in muscular tension of the parts of the arms and shoulders (Figure 9) Therefore, it is expected that the clinging strength of the hands acting together will differ from the combined clinging strength of the hands tested singly. As a rule, the combined strength of the two hands in unilateral clinging was greater than the strength of the two hands in bilateral clinging Infants in general gripped more strongly with one hand than with the other. Tables 6 and 7 show that the left hand was usually the dominant hand In a few isolated instances infants gripped as strongly with one hand as with both hands.

Anomalies in clinging occurred. Older infants sometimes gripped the stirrup bilaterally but would grip with neither hand or with one hand only when the stirrup was unilaterally presented Other infants grasped with one hand only, regardless of the manner of presentation of the stimulus

The investigation shows that the amount of pressure exerted on yielding objects by the hand and by the individual fingers in the proprioceptive situation appears to follow a physiological law, i e , the amount of pressure varies directly with the resistance of the object Now "the special feature of the reflex is that impulses from tension receptors within the muscle cause its development" (9, p 47). If, then, as Sherrington and his colleagues state (9), a small pull on a muscle activates a few tension receptors, whereas a strong pull activates a greater number of receptors, the resistance of a low pressure capsule will be met by a weak reflex, whereas the resistance of a high pressure capsule will be opposed by a correspondingly strong reflex This conclusion is also in accord with what occurs when the investigator pulls on a rod held by an infant; namely, the stronger the pull, the greater the resistance to the pull by the finger flexors

The results show that long-fingered infants were superior to short-fingered infants in clinging strength Similarly, investigation of the proprioceptive response in the individual fingers shows that the third finger (the longest digit) led its fellows in clinging strength In addition, results obtained in grasping a yielding object indicate stronger pressure by the middle finger than by the other fingers From the standpoint of mechanics the fingers in gripping represent a system of levers in which the proximal interphalangeal joints serve as the fulcrum. In clinging, a given rod presses against a point which is relatively closer to the joints of the long fingers than to the joints of the short fingers Thus the advantage in gripping leverage lies with long-fingered infants (There were no outstanding sex differences in finger lengths) Although fingers varied greatly in diameter, infants with long thick fingers were not superior to infants with long slender fingers in clinging strength.

Greater grasping strength was manifested in clinging to the small rod (3/16 inch diam.) than in clinging to the large rod (1 cm diam.). In addition, more infants supported their entire weight from the small rod than from the large rod. The principle of the lever is again applied in explanation of this fact. Of the two rods the smaller one fits closer to the joint of a flexed finger. Therefore, in clinging, the smaller rod presses against a given phalanx at a point so close to the joint (fulcrum) that a relatively great force is required to overcome the flexor strength (finger leverage). A large rod presses at a point more remote from the joint, hence the force required to overcome the strength of finger flexion is relatively weak.

The grasping reflex was more consistently and strongly expressed by the 3 ulnar fingers than by the forefinger. In fact the forefinger often failed to respond with the others in both closure and gripping situations. Thus its aloofness from the other fingers appears early in life. The unusual display of strength by the three ulnar fingers in gripping was noted by Mumford (35) in 1897.

The grasping reflex functioned with greater readiness and strength for active and for hungry infants than for passive or satiated infants. The strength of the reflex diminished during the transition from hunger to satiation. Frustration (withholding food) during hunger produced rapid and extensive fluctuations in the strength of the static stretch reflex. No noteworthy sex differences in gripping strength appeared in the feeding situation.

Other conditions which contributed to the variability of the early grasping response were: age differences (21), inconsistencies in stimulation, postural changes, differences in the force of the pull on the flexor tendons, and differences in degree of flexion of the fingers at time of presentation of stimulus.

The very fact that the early grasping response is a 2-component activity instead of a simple reflex complicates analysis of the factors which contribute to the variability of the response. If one component varies in speed or vigor, the other may vary in similar manner. For example, if an infant closes the fingers slowly he will probably tighten them slowly with little display of energy; or he may close and grip with one swift movement in which it is impossible to separate the two activities. At other times one component varies with the other in a manner which gives them the appearance of being physiologically independent activities (21) As an illustration, an infant may close the fingers slowly without apparent effort but, upon contacting an object within the palm, go to sudden gripping; or, as another illustration, palmar stimulation may fail to evoke finger closure, whereas a "pull" against the flexors will call forth a quick strong proprioceptive reaction Again, infants often close on an object placed against the palm without gripping it, or they will grip with one hand and only close with the other

The closure reflex was often delayed This investigation and an earlier study (21) show that the amount of stimulation required to evoke closure varied greatly in time and that frequently this response occurred only after prolonged stimulation Closure time, gripping time and the interval separating these activities also varied greatly

The presence or absence of the grasping reflex is frequently determined by noting whether or not an infant closes his fingers on an object placed against his palm. If the fingers close on it, the reflex is present, if they do not close on it, the reflex is no longer present (21, p 47). The other method for determining the presence of the grasping reflex is to place a rod against the infant's palm, close the fingers on the rod (if the infant does not close them), and pull on the rod If the infant resists the pull, the reflex is present, if he does not resist the pull, the reflex is no longer present. It is apparent that these two methods differ with respect to the manner of stimulation and also to the nature of the response In fact the responses obtained by the two kinds of stimulation stand in direct contrast physiologically. The first method seeks to evoke finger flexion by means of cutaneous stimulation; the second seeks to evoke gripping by proprioceptive stimulation The first method seeks to flex the fingers, the second to extend them. Thus the first method intends no opposition to flexion; the second intentionally opposes flexion to evoke stronger flexion.

Confusion concerning the early grasping response is due in part to failure of investigators to distinguish between the closure reflex in response to palmar stimulation and the proprioceptive reflex due to stretching the flexor tendons of the fingers. When the investigator places an object lightly against the infant's palm the grasping response, if it occurs, follows 1 of 3 courses The fingers may flex without closing on the object; they may flex enough to press lightly against the object, or they may flex tightly on it as in clinging In the latter instance the gripping is probably due to the stretching of the flexor tendons The fingers in closing customarily come to rest with their tips near or against the palm When their course is blocked by the presence of an object, the resistance thus unexpectedly introduced to flexion stimulates into action the proprioceptive response When the investigator pulls on an object in the infant's hand the proprioceptive reflex is immediately evoked This reaction which is a clinging response is essentially identical with the infant's clinging response in supporting his weight Physiological differences are to be found in the number of muscle fibres which respond in each case, because the greater the pull, the greater the number of motoneurones (and muscle fibres) excited to action (9, pp 47-48) Inasmuch as measures of the strength of the grasping response are always obtained either by the "blocking" or by the "pulling" method, these measures indicate the strength of the proprioceptive reflex

During the first few weeks of life the infant's hands are predominantly closed. As a matter of fact his hand often must be pried open for insertion of the object. Thus when an object is placed against the palm, the customarily flexed fingers will most probably close on the object This closure reaction may not occur during sleep or after feeding In clinging, infants hold on to the rod because they cannot release their grip. The stronger the pull against the fingers, the greater the strength of the "stretch reflex" so evoked

That the closure and "stretch" components are separable is shown by responses to palmar stimulation with the balsa paddle and the camel's hair brush These responses indicate that light pressure stimulation only infrequently evokes the "stretch" reflex. The fingers usually close slowly, generally with the terminal joints extended (giving the impression of searching or feeling for the stimulus object). If the fingers do not contact the object, they often fail to close against the palm

In this connection it is significant that the infant who goes directly to gripping, flexes all joints of the fingers sharply so that their tips point into mid-palm. The infant who first closes the hand before he grips, flexes the fingers relatively slowly The tips of the fingers describe a greater arc and come to rest against the palm near the wrist

An earlier study (21) differentiates these grasping components In 103 of 130 grasping responses by infants of 4 to 20 weeks of age, closure and gripping were separately timed

The distinction between finger closure and the "stretch" reflex is seen in instances of "forced grasping" in adults with lesions of the pre-moter area of the cortex Adie and Critchley (1) state that the patient may be able to manipulate objects with the fingers Light stroking of the palmar surface causes a slow clasping movement of the fingers, whereas objects placed against the palm are held in a "cramplike" grip Walshe and Robertson (52) recognize two distinct and separable grasping phenomena which are associated with frontal lobe lesions, viz, a volitional[11] component which consists of finger closure elicited by tactual or visual stimulation and a reflex component—a tonic innervation, or "stretch" reflex, elicited by pulling on the flexor tendons The reflex component corresponds to the clinging (proprioceptive) response in infants, whereas the volitional component has its counterpart in early finger closure In the infant, however, closure has not as yet attained the status of a voluntary activity. In this connection Jacobsen (26) finds that extirpation of the pre-motor area of primates results in forced grasping and in transient loss of the finer movements of the fingers

Stretch reactions are classified as "phasic" and "static" When a tendon is suddenly stretched it responds with a jerk or "phasic" reaction. A slow continued pull on the tendon gives rise to a sustained or "static" reaction (9, p 50). Both of these types of response, as well as closure, function effectively in grasping during early infancy Finger closure is the first of these responses to disappear. The "static" reaction weakens rapidly during the second half year of life

Under normal conditions the "phasic" reaction functions in the finger flexors throughout life. If a rod is placed against the volar surface of the terminal joints of the loosely flexed fingers and pulled suddenly, the immediate response is a flexing movement of the fingers in opposition to the pull. Knowledge of the nature of the response and efforts to avert its occurrence affect the reflex but little. Immediately after the occurrence of the reflex, the adult can extend the fingers and release the rod In other words, continued pulling does not further stimulate the flexors reflexly With the young infant, however, continued pulling on the rod remains an effective stimulus for the "stretch" response. In experiments on cats and dogs it has been noted that "in anaesthesia and in circulatory collapse" the "phasic" reaction continues to function long after the "static" response has disappeared (9, p 51).

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[11] Whether or not finger closure in this instance is volitional or reflex does not concern the writer (15) The recognition of the closure and "stretch" reactions as distinct grasping responses is the significant thing

A characteristic feature of the closure component is that its activity is more or less confined to the fingers Complete closure is attained when the digits contract fully against the palm without stretching the flexor tendons Although the proprioceptive component is most apparent in the fingers it is not an isolated activity. It exceeds closure both in vigor and in capacity to excite other reflexes. A pull on the fingers produces a stretch in the flexors of all joints of the arm. The elbow flexors in particular manifest a powerful proprioceptive reflex, while the wrist often contracts strongly. In bilateral clinging the legs are drawn up sharply by the powerful hip flexors, and in very strong bilateral clinging arm posture resembles that of adults in "chinning" In any event the proprioceptive response is not confined to the hand. From the principle of "functional facilitation from overlap of central connexions" (9, p 70) it follows that the pull on the finger flexors sets off a sequence or mass (24) of proprioceptive reflexes, which in early infancy involves not only the arm but a considerable number of the joints of the body (see Figure 6)

The distinction between finger movement and "stretch reflex" is further shown in an earlier study (21) in which tactual stimulation of empty closed hands evoked anticipatory extension of the fingers Results obtained in the normative study of infants at the Yale Clinic (17, p. 110) confirm this statement In this respect an empty flexed hand contrasts with a hand grasping an object in that in the latter case the object generally evokes the static proprioceptive reflex. Thus fingers not engaged in grasping enjoy a certain degree of freedom of action, fingers employed in gripping are limited to this activity. In this connection Schuster and his colleagues (43, 44, 45) state that in cases of forced grasping, if a clenched hand was empty, voluntary relaxation of the fingers was easy. Freeman and Crosby (14) observed reopening of the hand when the object was not grasped Adie and Critchley (1) noted that the patient was unable to open his hand unless the object was removed

It was previously stated that voluntary release begins at 28 weeks or later and that such release must be accomplished against a resisting surface. Release without resistance begins at about 44 weeks In any case release (almost without exception) does not occur during the first 24 weeks, although, according to most authorities on infant psychology, the grasping reflex disappears before or at this time There are, however, great individual differences in release ability, and it is this fact which accounts in large part for the very gradual disappearance of the clinging response (or static reaction) during the second half of the first year Difficulty in release of objects even at 1 year or later has been observed by Gesell (16), Freeman and Crosby (14) and Halverson (20). It is interesting to note that inability to release objects is the outstanding characteristic of forced grasping (1, 14, 15, 26, 43, 44, 45, 52).

The gripping reaction is one of the many primitive adient (22) responses common in human infancy. These responses are well tracked (canalized) If, when one of these responses is evoked, its customary course of action is barred, the infant suffers frustration in attainment of his goal Frustrations occur early in life Withholding food from a hungry baby is one way of producing frustration.[15] Although the infant's reactions in this situation are more or less diffuse (24, 34), they have the appearance of agressive behavior He threshes about, alternately strains and relaxes his muscles, kicks, cries vigorously, rolls and twists. Pulling on a rod held by an infant is another method of producing frustration. Although the infant's movements are limited in scope and direction, the flexors, his dominant muscles, so function that the strongest movements are directed centrally (21). One of the earliest of these adient movements is the hand-to-mouth reaction The supine infant offers little resistance to changes in posture of the arms which involve only flexion. Extension of the joints, particularly elbow and fingers, however, is actively resisted by the flexors of these joints, and, as already stated, the amount of such resistance varies directly with the force producing extension An active infant holding a rod may wave it about or keep the hand in one position. If the experimenter pulls on the rod the flexors of the infant's arm contract to carry it medianward. In clinging, flexor resistance, which is reflected by muscular tension and is measurable, frequently reaches a point at which the infant by trunk contraction, sharp hip flexion, facial contortions, body throwing, and strident crying, frequently referred to as angry crying (4), strongly protests and opposes the pull.

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[15] The above study of frustration will appear in a later paper.

The resistance, as indicated by its physical and emotional components, often assumes a very aggressive aspect Despite the fact that the cortex at this time of life functions very incompletely, attempts at reinstatement of the situation may be greeted by a new outburst of strong crying, accompanied by sharp, abrupt trunk, arm, and leg movements. The hand frequently must be captured before the rod can be inserted in the palm and the ensuing grip is unusually strong.

In general, investigators of the grasping reflex have confined their studies to infants of 12 weeks or less and then contented themselves with the statement that the reflex weakens as voluntary grasping begins While this statement is probably true, it gives little indication of the date of disappearance (usually set at 4 to 6 months) of the reflex. Interest in the strength of the proprioceptive aspect of the response has overshadowed interest in its variability and duration

Investigators naturally have set the date for the disappearance of the early grasping response in accordance with the time at which that phase of the reflex under observation failed longer to function. Thus it is most probable that failure of closure and absence of the clinging response would be reported at different dates One who was not particular would date the disappearance in terms of the absence of either or both of the components Finally, conditions which have been found to affect the response, i e , hunger, satiation, sleepiness, etc , may probably have been overlooked in determining the presence or absence of the reflex

The time of disappearance of the grasping reflex should be determined with respect not only to the absence of finger closure in response to palmar stimulation but also to ability to release a prehended object Infants can prevent the hand from closing on an object contacting the palm at an age when they cannot open the hand to release the object This inability to extend the fingers sig-

14 Objects of different materials have equal stimulus value in eliciting reflex grasping

15. The time of disappearance of the grasping reflex is determined in terms of its components The closure reflex apparently disappears at 16 to 24 weeks Its proprioceptive component disappears after 24 weeks Traces of the "static" reaction were present in one infant at 52 weeks

16. The grasping reflex is variable in readiness of response, speed of closure (21), duration of grip, strength of grip, and continuity of function of its two components.

17. Differences in method of evoking the grasping reflex account to a great extent for reported inconsistencies in its strength and time of disappearance

18 Closure is confined almost entirely to activity of the hand Its proprioceptive component is a vigorous and diffuse response, the peculiar property of which is its capacity to excite into action other reflexes both near and remote

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SHORT ARTICLES AND NOTES

A NOTE ON RESISTANCE AND RAPPORT IN PSYCHOLOGICAL TESTS OF YOUNG CHILDREN*

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Preschool children seldom fail to resist psychological tests, as a whole or in part (2). Pronounced resistance at the outset is less common than resistance to items within the test itself and presents a more difficult problem to the examiner, since effective handling of resistance during a test depends in some measure on the rapport that has already been established. It has been suggested (3) that emotional outbursts at the start of a test impair test performance; previous orientation experience with the examined is valuable in preventing outbursts of this kind, and postponement of the test experience is perhaps the most feasible method of meeting the difficulty in many instances.

The cases cited here illustrate procedures that proved effective in handling pronounced initial resistance, without decrement in test score in so far as could be determined. In the first case, information on the child's mental status was urgently needed; the effectiveness of postponement was questionable in the light of what was known of his previous experiences with intelligence tests. In the second and third cases, although the children might have accepted the tests happily at a later sitting, the examiner succeeded in obtaining a satisfactory test by using procedures similar to those proved effective in the first case. This report is offered for the purpose of suggesting types of procedures that may prove fruitful. A particular procedure varies in effectiveness with both the child and the examiner.

R. F., a boy of 42 months, came to us with a history of "non-testable." On the day of his test, following three weeks of nursery school experience, R. was accompanied by the head teacher to the psychological laboratory. The teacher directed him to stay with the examiner, reassured him about his return to the group later, and left. R. protested verbally, wept, and physically resisted her departure. The examiner placed R. at the testing table and encouraged him to cease crying. One or two tests were presented in an attempt to arouse his interest, without success. R. refused to touch the materials, continued to weep copiously and demanded that he be returned to the nursery school. The examiner explained that he might return after some of the games had been done, and then turned away from him and busied herself with note-taking. R.'s protests continued but became less and

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less energetic in the ensuing minutes The examiner left *R* alone at the table to answer a telephone in another part of the room *R* ceased to cry when the examiner began to speak When she completed the call and returned to the table, *R* was busily engaged with the materials on the table. The test then proceeded with optimum rapport

S.H, a girl of 32 months, refused verbally and wept when invited to come to the testing room. When urged to control her outburst, she came quietly but cried loudly as soon as she reached the room, withdrawing toward the door when she was asked to sit down. The examiner explained that she might return soon to the group and continued with preparations for the test *S* was invited to use a peg board, which she refused The examiner made no comment on the refusal and did not urge her further, but built instead a high block structure near the edge of the table In reaching for some materials from the nearby shelves, the examiner intentionally upset the block structure When the examiner started to retrieve the blocks from the floor, commenting on her own carelessness in spilling them, *S*. burst into voluble talking about the blocks, helped the examiner to pick up the few remaining, seated herself and proceeded amiably with the test She chose the peg board which had been refused as one of the first games to do

J C, a girl of 30 months, came to the testing laboratory without comment, but withdrew and wept when invited to sit down The examiner seated her, presented a simple game, and explained that several games were to be completed before she was ready to return to the nursery school *J* drew away from the table and the materials, weeping, and the examiner withdrew from the table and wrote. No further attempts to elicit performance were made for several minutes, the slightest move in her direction, however, caused *J* to withdraw further and to weep more copiously The starting of an automobile interrupted the usual quiet of the testing room. *J* burst into voluble talking about the automobile, and accepted the examiner's suggestion that she stand at the window so that she might see the car. *J* was lifted to the window and looked out at the cars in the driveway for a moment. She soon became restless and disinterested and asked to get down She was helped into her chair and then proceeded, without comment or further direction from the examiner, to complete the test near her on the table which had been refused a few minutes before No further difficulty was encountered in administering the remainder of the test

S H and *J C* were tested successfully on the Stanford-Binet scale several days later *R F* was tested only on the Merrill-Palmer, the test involved in the preceding accounts All three children stood in the 99th percentile on the Merrill-Palmer scale *S.H* achieved an *IQ* of 144 on Stanford, and *J.C.* an *IQ* of 129. Previous to the test experience, *R F* was acquainted with the examiner only thru her infrequent contacts with other children in the group for testing purposes *S.H.* and *J.C* knew the examiner as one of the part-time teaching staff in the nursery school Three weeks of nursery school experience preceded the mental tests of *S H* and *J C* *R T* had had sporadic nursery school experience in another institution.

The writer has made use of similar procedure in eliciting verbal responses from children who became embarrassed or resistant in verbal tests. Leaving the table, shuffling papers, sitting with her back to the child or walking about the room, were found to be fairly successful when adequate response could not be obtained in the ordinary face to face test position

The young child's resistance or embarrassment may arise from a misconception of the examiner's intent By putting herself in the rôle of disinterested onlooker, the examiner perhaps changes the child's conception of the test situation The examiner's participation in activities unrelated to the child's test response and the child's activities possibly indicates to the child that choice is involved rather than compliance It is noteworthy that Reynolds suggests that a "break" in the situation is more likely to be effective in overcoming resistance than continued insistence on performance of the resisted activity (1)

The withdrawal of the examiner and the occurence of a distracting event seem to help the child to reinterpret the test situation. In two of the instances cited, the distracting events were within the examiner's control (telephone, block building). In the third, interestingly enough, the child herself helped to create the distraction (trip to window).

The previous family experience of the three children described was similar in that all were the younger of two siblings. The extent and nature of their resistance in the test situation may have been influenced to some degree by similarity in family experience Since their nursery school experience was the same, so far as duration of acquaintance with the staff was concerned, greater or less familiarity with the nursery school was probably not important in obtaining successful response to the test situation

It must be noted that a relatively superior group of children are involved in the instance cited Limited experience with dull preschool children suggests that the use of "breaks," distractions, and seeming disinterest in the child's behavior may be momentarily effective in cases of extreme resistance, but does not produce lasting rapport The challenge of the test to the brighter child is no doubt of significance in producing this seeming difference between bright and dull children

Experimentation in another area of behavior tends to confirm the findings in intelligence test situations reported here, namely, that the adult may arouse a marked degree of cooperative behavior by remaining relatively aloof from the child and by directing the child's attention to a sudden stimulus before performance is required of him In these experiments also a relatively bright group of subjects was involved

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A NEW TYPE OF DOUBLE ALTERNATION*

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INTRODUCTION

In three earlier investigations it has been shown that white rats can master the problem of double alternation under favorable conditions (1, 4, 5). In one of these studies, made by the present writer, rats were given prolonged training in a situation somewhat comparable to that in which Hunter's raccoons (3) were successful. An elongated temporal maze of the elevated type was employed, the subjects were given a single trial daily, each trial consisting of four runs in *LLRR* (left-left-right-right) sequence, and reward was given at the end of each run. (The lengthening of running-distance in this maze was calculated to enhance any possible "cumulative effects" of successive runs.) Under such conditions both of the animals tested over a period of approximately 10 months reached a degree of mastery superior to that of Hunter's raccoons or the monkeys of Gellermann's maze experiment (2). As in other experiments on this problem, however, a high degree of stability of performance was not achieved by the animals within the time limits of the investigation, and it was considered that this might have been due to one or both of two factors: the delicacy of the discrimination involved, and a conflicting tendency toward simple alternation (*LRLR*). The experiment herewith reported was aimed at the removal of this second possible influence, and utilized a temporal maze of a new type. The results obtained, although inconclusive, suggest that mastery of double alternation may be more readily attained by rats when the possibility of simple alternation of the *LRLR* type is absent.

SUBJECTS, APPARATUS, AND METHOD

The subjects used were four female white rats of Wistar stock, three

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months old at the beginning of the experiment During the observational period, except for unavoidable breaks in routine, they fed together in their home-cage for two hours daily, after their runs through the apparatus. The food was Purina Dog Chow, occasionally supplemented with a few grams of lettuce or other fresh vegetables

The apparatus is represented in Figure 1 An enclosed runway, 3 inches wide by 7 inches high, with a wooden floor and ⅛ inch wire-mesh top and walls, was constructed in the pattern of a square with 20-inch sides (outside dimensions) At one side was a small door, also of wire mesh, giving access to the entrance-food compartment (*E F* in the figure). At the third turn in the runway, counter-clock-wise from *E-F*, was inserted a choice compartment with two chambers (*D* and *U*) approximately equal in size, one above and the other below the level of the runway itself A thin metal block (*A*), placed at the entrance to the first part of the runway, could be raised or lowered quietly between two grooved uprights by means of a cord and pulley Another block (*B*), of cardboard, was placed at the end of the choice compartment nearest to *E-F*, this block was so constructed as to permit blocking of either, neither, or both of the two

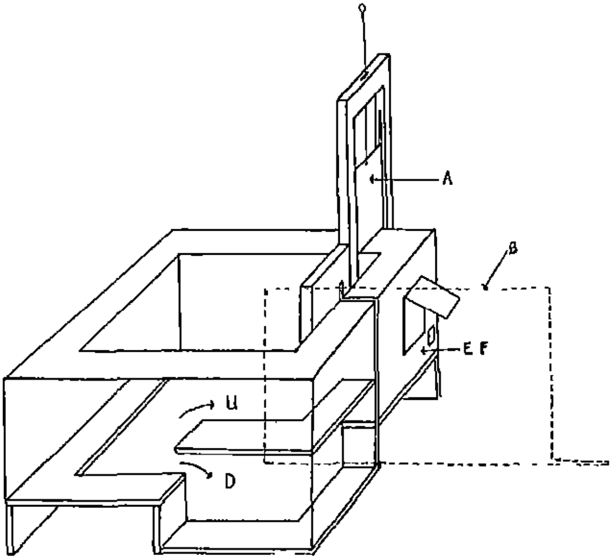

FIGURE 1
TEMPORAL MAZE
See text

chambers merely by a pull or push of a long wooden handle extending from the edge of the block to the experimenter A small hole in the wire mesh at the level of the rat's head and near the right-hand side of *E-F* permitted the insertion of pellets of food.

The whole apparatus was placed upon a deal table to one end of which was attached a three-foot-square cardboard screen that served to hide the experimenter from the view of the rat. A peephole in the screen permitted observation of the rat in *E-F* and after a given chamber of the choice compartment had been entered The handle to block *B* passed through another small aperture, and the cord to block *A* passed around the right-hand edge of the screen When food was put in *E-F* the experimenter reached around the right-hand edge of the screen, but this was done only after the animal had traveled through one of the choice chambers

In a given test the rat was brought to the maze in a carrying-cage and allowed to run into *E-F*. The cage was then removed and the door to *E-F* was fastened Both blocks were in place and the animal was detained until the experimenter had seated himself behind the screen Block *A* was then raised, letting the animal pass through the opening on his first run Simultaneously with the lowering of *A* behind the rat, block *B* was removed from both choice chambers In case of a run through the correct chamber, *B* was not moved until the rat entered *E-F* Then *B* was brought into position, blocking both chambers against retracing, and a small pellet of food (about 1/20 of a gram) was dropped through the hole in *E-F*. In case of an incorrect choice, only the chamber chosen was blocked by *B* and no further change was made until the rat reached *E-F* through the correct passageway Then *B* was pulled into full blocking position and the reward was given. When the food was eaten, the animal was ready for his next run, under the same conditions of blocking.

Prior to the introduction of the double-alternation task each animal was given 150 runs in the apparatus (10 runs daily) with neither choice chamber blocked During this period three rats chose the lower path predominantly from the first, rat No 1 alone showed an initial preference for the *U*-path, which gave way in the last 50 runs to the *D*-choices. (In none of the animals did there appear any tendency toward simple altera-

TABLE 1
PATHWAY PREFERENCE OF RATS IN THE "UP-DOWN" TEMPORAL MAZE PRIOR TO TRAINING IN DOUBLE ALTERNATION

	Rat 1 Choices		Rat 2 Choices		Rat 3 Choices		Rat 4 Choices	
	D	U	D	U	D	U	D	U
1st 50	2	48	46	4	40	10	38	12
2nd 50	12	38	50	0	49	1	43	7
3rd 50	42	8	49	1	49	1	44	6

tion of the *DUDU* type.) This may be appreciated by a glance at Table 1 in which the choices of each rat are recorded in groups of 50 runs each.

On the day after these free runs the training in double alternation began. The method has been outlined above. Each rat was given one trial daily—four successive runs. The task set was a *DDUU* sequence of choices. On the first two runs the animal was blocked only if he entered the *U*-chamber at the end of his run around the maze; on the second two runs he was blocked only in the *D*-chamber. (Both chambers were of course blocked behind him after he reached his reward at *E-F*.) Reward was given at the end of each of the four runs whether or not blocking or retracing had taken place.

RESULTS

During an 8-months' period rats 1, 2, 3, and 4 were given 166, 167, 159, and 165 trials respectively. The composite curves shown in Figure 2 represent the progress of all the rats in the last 150 trials. The unit employed in the lower curve is ten trials, that for the upper curve is 40 runs. Table 2 shows the number of the most common sequences of runs chosen by each rat in all the trials given.

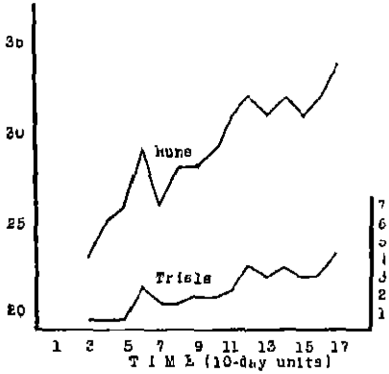

FIGURE 2

COMPOSITE CURVES SHOWING PROGRESS IN MASTERY OF DOUBLE ALTERNATION

As in earlier experiments of this sort, there is some difficulty in designating a satisfactory criterion of mastery. If the problem is considered one of maze-learning, the standard will be a given number of successive correct trials (Hunter chose three in his 1929 experiments); but if the task is taken to be one of discrimination, the criterion will be in terms of percentage of correct runs in a stated period of time.

In terms of successive correct trials, rats 1, 2, and 3 achieved as high

TABLE 2

FREQUENCY OF MOST COMMON SEQUENCES CHOSEN DURING TRAINING IN DOUBLE ALTERNATION

	Rats			
Choices	1	2	3	4
DDUU (Correct)	56	19	40	20
DDDU	36	51	23	72
DUUU	35	5	29	1
DDUD	12	26	15	23
DUDU	13	18	17	28
DDDD	5	29	6	12
All others	9	19	29	9

as four, four, and six, respectively. (Rat 4 did not exceed a succession of two during the entire experiment.) In addition, rat No. 1 reached a succession of three on four occasions, and rat No. 3 also reached one succession of five and one of three.

With respect to percentage of correct runs out of 40 (ten successive trials) the figures for rats 1, 2, 3, and 4 are 90, 87½, 95, and 85. As in the case of the other criterion it is clear that, with the exception of one rat, a high standard of performance was attained—a standard unequalled by Hunter's raccoons, Gellermann's monkeys (tested with the maze), or the rats of the writer's earlier study.

CONCLUSIONS AND DISCUSSION

The evidence cited permits the conclusion that white rats are able to master this new type of double-alternation problem with a degree of success not previously reported in the literature. Further generalization with respect to the relative value of this method in the analysis of the temporal-maze habit is impossible at the present time because of (*a*) the small number of subjects in this and the above-mentioned experiments, and (*b*) the degree of instability that still characterizes the habit. The first of these obstacles suggests the means of its avoidance, but the second is not so easily to be met and it is more important. Until greater stability of behavior is demonstrable the insertion of various control tests cannot provide unequivocal results with respect to the analysis of the mechanism involved.

Whether the elimination of the possibility of a simple *RL* alternation in the present method is responsible for the better performance of our subjects is, obviously, questionable. Nevertheless, it may be pointed out that no definite tendency toward simple *DU* alternation showed itself in this experiment, either in the preliminary or problem runs. Moreover, a later attempt to establish a simple-alternation habit (*DUDU*), in another group of rats, points in the same direction. In 48 trials, following 150 preliminary runs, there was even less indication of progress than in the double-alternation tests during a comparable period of training

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